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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 69
1959

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RICHARD A. LAUBENGAYER, Editor
Wabash College
Crawfordsville, Indiana

•

Spring Meeting
May 15-16
McCormick's Creek
State Park

Fall Meeting
October 29-31, 1959
BUTLER UNIVERSITY

Published at Indianapolis, Indiana
1960

1. The permanent address of the Academy is the Indiana State Library.

2. **Instructions for Authors** appear at end of this volume, P. 340.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

John Shepard Wright Memorial Library of the Indiana Academy of Science.
c/o Indiana State Library
Indianapolis 4, Indiana.

4. **Proceedings** may be purchased through the State Library at $3.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and By-Laws reprinted from v. 62 and the Membership List reprinted from v. 67, are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Biology Department, Wabash College, Crawfordsville, Ind.

Papers published in the Proceedings of the Indiana Academy of Science are abstracted or indexed in appropriate services listed here:

Annotated Bibliography of Economic Geology

Bibliography of Agriculture

Bibliography of North American Geology

Biological Abstracts

Chemical Abstracts

Chemisches Zentralblatt

Current Geographical Publications

Geological Abstracts

Mathematics Reviews

Metallurgical Abstracts

Psychological Abstracts

Review of Applied Entomology

The Torrey Bulletin

Zoological Record

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Fall Meeting: October 29, 30, 31, Butler University, Indianapolis, Ind.

OFFICERS FOR 1959

President.....R. E. Cleland, Indiana University
Vice-President.....A. T. Guard, Purdue University
Secretary.....H. E. Crull, Butler University
Treasurer.....D. J. Cook, DePauw University
Editor.....R. A. Laubengayer, Wabash College
Press Secretary.....F. N. Young, Jr., Indiana University

CHAIRMEN OF THE DIVISIONS

Anthropology.....G. K. Newman, Indiana University
Bacteriology.....W. A. Zygmunt, Mead-Johnson Research Labs.
Botany.....C. B. Heiser, Jr., Indiana University
Chemistry.....F. Welcher, Indiana University, Adult Education Center
Entomology.....J. Davis, Purdue University
Geology and Geography.....R. W. Lounsbury, Purdue University
History of Science.....S. S. Visher, Indiana University
Mathematics.....G. N. Wollen, Purdue University
Physics.....M. Dixon, Butler University
Plant Taxonomy.....S. McCoy, Technical High School, Indianapolis
Psychology.....C. Josey, Butler University
Soil Science.....C. W. Guernsey, Purdue University
Zoology.....F. Fuller, DePauw University

EXECUTIVE COMMITTEE

(Consisting of Past Presidents, Current Officers, Divisional Chairmen, and Chairmen of Standing Committees)

Bessey, W. H.
Christy, O. B.
Cleland, R. E.
Coats, N. M.
Cook, D. J.
Crull, H. E.
Cumings, E. R.
Daily, W. A.
Davis, J. J.
Deay, H. O.
Degering, D. F.
Dixon, M.
Edington, W. E.
Edwards, P. D.
Fletcher, R.
Fuller, F.
Girton, R. E.
Guard, A. T.
Guernsey, C. W.
Heiser, C. B., Jr.
Johnson, W. H.
Josey, C.
Just, T. K.
Klinge, Paul
Laubengayer, R. A.
Lilly, Eli
Lounsbury, R. W.
Mackell, J. F.
Markle, C. A.
Markle, M. S.
McCoy, S.
Meyer, A. H.
Michaud, H. H.
Morgan, W. P.
Newman, G. K.
Payne, F.

Polley, J. C.
Porter, C. L.
Powell, H. M.
Schultz, R. W.
Visher, S. S.
Wallace, F. N.
Weatherwax, P.
Welch, W. H.
Welcher, F.
Wollen, G. N.
Young, F. N., Jr.
Yuncker, T. G.
Zygmunt, W. A.

BUDGET COMMITTEE

Consisting of President, Secretary, Treasurer, Editor, Chairman of Junior Academy, Library, Program, and Relation of Academy to State: R. E. Cleland, H. E. Crull, D. J. Cook, R. A. Laubengayer, H. H. Michaud, N. M. Coats, W. H. Bessey, F. N. Wallace.

COMMITTEES ELECTED BY THE ACADEMY

Trustees of the Academy Foundation (term 4 years): Chairman, Ward J. Rice (term expires 1960), J. E. Seybert (term expires 1961).

Bonding of Trustees (elected annually): Chairman, Scott McCoy, Technical High School, Indianapolis; F. J. Welcher, Indiana University, Adult Education Center, Indianapolis.

Research Grants (term 5 years): Chairman, T. G. Yuncker, DePauw University (term expires 1959); Paul Weatherwax (1961); A. A. Lindsey (1963); J. F. Hart (1962); R. E. Cleland and H. E. Crull (ex officio).

COMMITTEES APPOINTED BY THE PRESIDENT

Auditing: Chairman, W. P. Morgan, Ind. Central College; F. J. Welcher.

Biological Survey: Chairman, C. A. Markle, Earlham College; F. K. Daily; D. G. Grey; C. J. Goodnight; H. H. Michaud; W. H. Welch; F. N. Young, Jr.; J. Webster.

Fellows Committee: H. O. Deay, Chairman; H. H. Remmers, Psychology, Purdue University; H. Driver, Anthropology; A. T. Guard, Botany; L. S. McClung, Bacteriology; K. Seymour, Chemistry; H. O. Deay, Entomology; T. F. Barton, Geology and Geography; M. S. Markle, History of Science; P. D. Edwards, Mathematics; A. C. Mitchell, Physics; F. K. Daily, Plant Taxonomy; N. Pearson, Zoology.

Index: Chairman, R. A. Laubengayer, Wabash College; Nelle Coats; F. N. Wallace.

Indiana Talent Search: Chairman, R. S. Schulz, Purdue University; L. N. Baldinger; P. D. Edwards; C. A. Markle; M. Correll; Sears Crowell.

Invitations: Chairman, A. H. Meyer, Valparaiso; M. Hall; J. F. Mackell.

Junior Academy: Chairman, H. H. Michaud, Purdue University; N. E. Adams; R. Cooper; P. E. Klinge; Lola Lemon; R. E. Martin; R. E. Niswander; R. W. Schulz; J. Cope.

Library: Chairman, N. M. Coats, State Library; Eli Lilly, G. Black.

Membership: Chairman, R. Fletcher, DePauw University; John A. Buehler, Anderson College; Louis E. Delanney, Wabash College; H. M. Dixon, Butler University; M. R. Garner, Earlham College; E. Kintner, Manchester; R. E. Martin, Hanover College; D. F. Johnson, Indiana State Teachers College; Charles Brumfiel, Ball State Teachers College; K. N. Campbell, Mead-Johnson Research Labs.; D. Den Uyl, Purdue University; L. Farquharson, Franklin College; G. Hennion, University of Notre Dame; R. G. Larson, Valparaiso University; G. R. Miller, Goshen College; F. J. Zeller, Indiana University.

Necrologist: W. E. Edington, DePauw University.

Program: Chairman, W. E. Bessey, Butler University; K. Seymour, E. Rowe, V. Kavanaugh, S. McCoy, C. B. Heiser, Jr.

Publication of Proceedings: Chairman, R. A. Laubengayer, Wabash College; A. A. Lindsey, F. Hart.

Publicity: Chairman, F. N. Young, Jr., Indiana University, W. H. Bessey, C. Theophanis.

Relation of Academy to State: Co-Chairmen, F. N. Wallace, Dept. of Conservation, and W. A. Daily, Eli Lilly; J. A. Clark; Eli Lilly; H. J. Reed; R. A. Laubengayer.

Representative on Council of the AAAS: C. B. Heiser, Jr., Indiana University.

Resolutions: Chairman, W. Johnson, Wabash College; F. Hart, E. T. McBee.

Science Education: Chairman, Paul Klinge, Indiana University; K. Dale, R. Lefler, W. Smith, R. S. Schulz.

Indiana School and College Committee on Mathematics: Chairman, J. C. Polley, Wabash College; G. N. Wollen, G. Vannatta.

SPRING MEETING
EXECUTIVE COMMITTEE MEETING

McCormick's Creek State Park

May 15, 1959

4:30 P. M. CDT

The meeting was called to order by Pres. R. E. Cleland at 4:35 p. m. CDT.

The following reports were presented:

Treasurer—Donald J. Cook (read by H. R. Youse):

Balance on Hand January 1, 1958		$9,469.93
Receipts		
Dues and Initiation Fees	$3,434.50	
Publications sold	103.05	
Authors' reprints, Vol. 64	20.62	
Authors' reprints, Vol. 65	88.12	
Authors' reprints, Vol. 66	502.74	
Authors' reprints, Vol. 67	320.77	
Designated gift	50.00	
Talent search	1,492.50	
		6,012.30
Disbursements		
Editor, Vol. 67	$ 225.00	
Expenses of Secretary	160.05	
Expenses of Treasurer	177.04	
Stationery	215.60	
Talent Search	1,358.03	
Program Committee	300.75	
Research Grants	522.67	
Mailing *Proceedings,* Vol. 67	54.55	
Returned checks	13.20	
Error in deposit	2.00	
Expenses of six officers	125.00	
Academy Conference	29.35	
Reprints, Vol. 67	665.03	
J. S. Wright Memorial Library	1,461.63	
Junior Academy of Science	14.24	
Binding, Memorial Library	699.50	
Publishing *Proceedings,* Vol. 67	209.15	
AAAS	8.50	
		6,241.29
Balance on hand December 31, 1958*		$9,240.94

* Includes $4,299.41 in the John Shepard Wright Memorial Library fund and $1,878.54 in the Talent Search fund.

Editor—Richard A. Laubengayer: Mr. Laubengayer reported that the galley proofs had been corrected and returned to the printer's for the final printing. The appropriation for biennium was approved.

Library—Nelle Coats: A collection of photos of presidents was discussed, and Mr. Daily remarked that ample storage space was available for photos and historical material. Kraus Periodicals has supplied scarce items for the files for which $1,658.99 was expended from the Lilly Endowment, Inc. fund. Other purchases totaled $95.76. These, together with the volumes to which they belong, have been prepared for binding by the State Library's Serials Librarian, Mrs. Lois Burton, and will shortly be delivered to the National Library Bindery, Indianapolis.

During a legislative year the State Library has many visitors including young people from many schools, and these as usual seemed especially interested in the Academy Library materials in the display case at the entrance to the building together with a map indicating cities on the exchange list in 80 foreign areas. It was reported last November that 983 domestic and foreign titles were currently received. The availability of copies of *Indiana Scientist* and other publications is as follows:

Indiana Scientists, 550 copies, free to 3-year members, price $2.50 ($1.50 to biographees or relatives).

Index volumes 1-50, 1891-1940, 500 copies, free to 5-year members, price $3.00.

Index volumes 51-60, 1941-1950 in *Proceedings* v. 61, 1951, total 295 (177 hard covers, 118 paper covers), price $3.00, $1.00 to members.

Press Secretary—F. N. Young, Jr.: Mr. Young presented a folder of press releases and requested that popular abstracts of papers be turned in in advance of the fall meeting.

Program Chairman—Wm. Bessey (read by Mrs. Fred Kavanaugh): The program of the present meeting was prepared by Prof. Charles B. Heiser, Jr., with no help from the rest of the committee. Some work has now been done on the fall meeting at Butler University, October 30, 31. We can have the business meeting and the general meeting in the Chemistry lecture room from 9:00 to 11:00 a. m. as previously. This room has a maximum seating capacity of a little over 250. If necessary, overflow crowds could be handled with public address systems in other rooms. If we prefer, we could hold the business and general meetings in the cafeteria which holds 360 with all the tables in place. In this case, the cafeteria *must* be emptied by 10:30 a. m. as students will be coming for lunch at 11:00 a. m. If we get a local person for the speaker for the general meeting, the chemistry lecture room will no doubt be amply large. If we bring in someone with a big reputation from out of the state (for example, former Hoosier Urey) we would probably find the large room necessary, but then would be cramped for time. So far, the following local people have been suggested to the committee as likely speakers for the morning session: Dr. J. N. McGuire, microbiologist, Eli Lilly & Co.; Dr. John S. Karling, botanist, Purdue University; Dr. Frederick N. Andres, Animal Science Department, Purdue University; Dr. Tracy N. Sonneborn, geneticist, Indiana University; Dr. George Kimball, geography, Indiana University; Dr. Frank Edmondson, astronomy, Indiana University. At least one member of the committee has objected to each one of these. Out of state people suggested are: Roger P. Wodehouse, Pearl River, New York,

to talk on "Allergies"; Wendell Stanley, Harold Urey, LeRoy Burney, Albert Noyes, Rollo May.

It was suggested that the main speaker follow the luncheon in the cafeteria. It was moved, seconded and passed that an effort be made to secure a speaker from the Institute of Tropical Medicine which will be meeting in Indianapolis at the same time.

Other Reports—A request has been made to the National Science Foundation for $16,750 to make available visits by scientists to high schools. The request has been approved.

New Business—Dr. Yuncker reported that $200-$300 a year was available for research grants from the AAAS. It was moved and seconded that the endowment fund interest less bank charges from the previous year be made available each year to the research grants committee. Any unused part would revert to the fund. This motion was amended to read that a maximum of $300 of the endowment interest be made available. The motion and amendment were passed.

Dr. Fletcher of the membership committee read a proposed folder on membership. The cost would be $27 per 1,000. It was moved, seconded and passed that the Academy secure 1,000 of these folders.

It was reported that the Academy was represented at the Academy Conference in December, 1958.

It was announced that Dr. Welcher had submitted his resignation as chairman of the chemistry division and that Dr. Lawrence Strong will be asked to serve in this position. It was moved that he be appointed to this position, and in the event that he could not accept, the president was authorized to appoint a successor to Dr. Welcher.

Dr. Edington suggested that the Committee on the Relation of the Academy to the State investigate the possibility of state printing.

The meeting was adjourned at 6:00 p. m. CDT.

Respectfully submitted,

HARRY E. CRULL, Secretary

SPRING MEETING
GENERAL SESSION

McCormick's Creek State Park

May 15, 1959

7:45 P. M. CDT

Words of welcome to members were given by Pres. R. E. Cleland. The officers of the Academy were introduced, and the Secretary's reports were read and approved. The Membership Committee reported that there were 15 new members. The following resolution was read by W. Johnson:

> The Resolutions Committee on behalf of all the members of the Indiana Academy of Science present wish to thank Dr. Charles Heiser of the Program Committee for his work in arranging for this meeting, Mr. Ray Myers, Manager of Canyon Inn, for providing us with comfortable facilities and a fine dinner, Dr. Charles Hagen for sharing with us some of his recent experiences in Trinidad, and finally the officers of the Academy for their efficient conduct of the meeting.

The Indiana Soil Science Society presented an award of recognition to Prof. Bushnell.

Mr. Charles W. Hagen, Jr., Indiana University, spoke on "Customs and Contrasts in Trinidad."

After Mr. Hagen's speech Saturday morning field trips were announced and the meeting was adjourned.

Respectfully submitted,

Harry E. Crull, Secretary

FALL MEETING
EXECUTIVE COMMITTEE

OBSERVATORY, BUTLER UNIVERSITY

October 29, 1959

The meeting was called to order by President R. E. Cleland at 7:30 p. m. The minutes of the Spring meeting were read by the secretary and approved as read.

Treasurer—Donald J. Cook: Financial report.

FINANCIAL REPORT OF THE INDIANA ACADEMY OF SCIENCE

Jan. 1, 1959 thru Dec. 31, 1959

Receipts

Balance on Hand—January 1, 1959	$ 9,240.94
Dues and Initiation Fees	3,722.50
Sale of Reprints: Vol. 66, 67, 68	229.83
Sale of Publications	71.00
Gifts	70.00
National Science Foundation Grant	16,750.00
A. A. A. S. Grants for Research	762.00
Academy Endowment Grant	300.00
Indiana Science Talent Search	1,465.00
John Shepard Wright Library	500.00
Returned Check	5.00

Disbursements

Editor—Volume 68 of Academy Proceedings	$ 225.00
Mailing Proceedings	36.76
Miscellaneous Expenses	17.06
Bond for Treasurer	62.50
Stationery	165.51
Expenses of Secretary	146.20
Expenses of Treasurer	183.70
Adding Machine for Treasurer	85.00
Expenses of President's Office	6.20
Expenses of Officers	125.00
Academy Conference	21.00
Research Grants	450.00
Indiana Talent Search	2,205.32
Junior Academy of Science	79.35
John Shepard Wright Memorial Library	3,076.68
Cost of Reprints: Volume 68	944.15
Additional Costs of Printing Volume 68 of Proceedings	872.24
Indiana Science Fairs	49.90
Visiting Scientists Program—National Science Foundation Grant G-8724	1,724.68
Program Committee	316.42
Binding—Academy Funds as Budgeted	998.95

TOTAL RECEIPTS:	$33,116.27
TOTAL DISBURSEMENTS:	11,791.62
Balance on Hand—December 31, 1959	$21,324.65

Balance on Hand, December 31, 1959:

Indiana Science Talent Search	$ 1,138.22
John Shepard Wright Library	1,727.73
National Science Foundation Grant G-8724	15,025.32
Indiana Academy Funds	3,433.38
($300 of Academy Funds designated for Research Grants)	

Editor—Richard A. Laubengayer: Copies of Volume 68 of the Proceedings of the Indiana Academy of Science were in the mail by the latter part of September. The lateness of mailing was due to unavoidable difficulties encountered by the editor during the early summer months. The Bookwalter Company delivered 1,197 bound and 580 paper copies, for a total of 1,777 copies, to the State Library. This was slightly under the number ordered but sufficient to satisfy demands. Thirty-seven of the contributors ordered reprints. The editor and committee wish to thank the members of the Academy, Miss Coats and Mrs. Burton of the library staff, and the Bookwalter Printing Company for their cooperation in the publishing of this volume.

Trustees of the Academy. Report by Harry E. Crull:

Income Cash Statement

October 1, 1958—Beginning Balance	$ 964.90
October 1, 1958–September 30, 1959—Total Receipts	399.78
October 1, 1958–September 30, 1959—Bank Fees	19.99
September 30, 1959—Ending Balance	1,344.69
Total Carrying Value Stocks and Bonds	14,354.02

Principal Cash Satement

October 1, 1958—Beginning Balance	6.34
September 30, 1959—Ending Balance	6.34

Press Secretary—F. N. Young: Notices of the 75th Annual Meeting of the Academy were sent to all Indianapolis newspapers and to the United Press International and Associated Press wire services. In addition releases on more than twenty individual papers were prepared and sent out over the state. Releases on the visiting scientist program and on some individual papers were released before the meetings and were published in several papers. A complete report with press clippings will be submitted at the spring meeting.

Research Grants Committee—T. G. Yuncker: The following grants have been made during the period since our last annual meeting in 1958: (1) Dr. W. H. Welch, DePauw University, $100.00 to aid in her work on the taxonomy of the moss family Hookeriaceae. (2) Dr. L. S. McClung, Indiana University, $100.00 for studies on the taxonomy of the genus Clostridium. (3) Mr. Scott McCoy, Arsenal Technical High School, $22.67 covering field collecting expenses. (4) Dr. Carrolle Markle, Earlham College, $100.00 for field and herbarium expenses connected with her work on the flora of Wayne County. (5) Dr. William Hopp, Indiana State Teachers College, $100.00 for experimental investigations on the growth rate of snakes. (6) Dr. Robert L. Henry, Wabash College, $150.00 for expenses connected with a problem involving the techniques of x-ray

defraction. (7) Dr. Lois I. Farquharson, Franklin College, $100.00 for expenses connected with genetical studies on the corn plant. (8) Dr. Emily J. Blasingham, Indiana University, $100.00 for an investigation on the archeology of Saline Springs, Gallatin County, Illinois. The increased number of grants for the current year was made possible because of an allotment of $300.00 for this purpose from the Academy funds at its last spring meeting. This money, together with that received from the AAAS, has now been expended and no further grants are possible at the present time. It was moved and seconded that at any time during each calendar year up to $600.00 may be appropriated for research grants, subsequently to be paid by the AAAS and by $300.00 of Academy funds. The motion was carried.

Nominating Committee—Carrolle A. Markle: Scott McCoy and Frank Welcher were nominated to succeed themselves for the Bonding of Trustees Committee. Nominated as members of the Research Grants Committee were T. G. Yuncker for a term of five years and Keith M. Seymour to fill the unexpired term of Melvin G. Mellon, who resigned.

Fellows Committee—Howard O. Deay: The following persons were recommended to be elected Fellows of the Indiana Academy of Science: F. J. Belifante, Physics, Purdue University; Malcom Correll, Physics, DePauw University; Dean Fraser, Bacteriology, Indiana University; S. D. Gerking, Zoology, Indiana University; John F. Hart, Geography, Indiana University; Vaclav Hlavaty, Mathematics, Indiana University; C. E. Kaslow, Chemistry, Indiana University; W. A. Konetzka, Bacteriology, Indiana University; L. L. Meritt, Jr., Chemistry, Indiana University; and E. D. Weinberg, Bacteriology, Indiana University.

Biological Survey Committee—Carrolle Markle:

Publications of 1958-1959 Dealing with the Flora and Fauna of Indiana

Algae:

1. Daily, Fay Kenoyer. 1959. Some Observations on the Occurrence and Distribution of the Characeae of Indiana. Proceedings of the Indiana Academy of Science **68**:95-107.
2. Daily, William. 1959. In search of Some Blue-Green Wanderers. Presidential Address. Proceedings of the Indiana Academy of Science **68**:43-57.
3. Eberly, William. 1959. The Metalimnetic Oxygen Maximum in Myers Lake. Invest. Indiana Lakes and Streams Vol. V. No. I:1-46

Bryophyta:

Miller, H. A. and J. W. Thompson. 1959. The 1958 Foray of the American Bryological Society. (Held in Putnam and Parke Counties, Indiana.) The Bryologist **62**:67-73.

Vascular Plants:

Humbles, Jack. 1959. Preliminary Studies of **Desmodium** Populations in Southern Indiana. Proceedings of the Indiana Academy of Science **68**:319.

Aves:

1. Baker, Mrs. H. A. 1958. Breeding Bird Census—Two Hay Fields and Grazed Creek Pasture. Audubon Field Notes **12**(6):450-451.
2. Various Authors. 1959. 12 Christmas Bird Counts Numbers 326-337. Audubon Field Notes **13**(2):182-185.

Work in Progress or Completed in 1958-1959 But Not Yet Published

Fungi:
Brown, Mary J. Some Fungi on the Oakland City Campus.

Bryophyta:
1. Nebel, Bernard. Studies in Mosses of Wayne County, Indiana.
2. Welch, Winona H. Studies in Indiana Bryophytes XII.

Vascular Plants:
1. Davidson, Thomas. The Flowering Plants of Grant County, Indiana.
2. Humbles, Jack. The **Desmodium paniculatum** Complex in Southern Indiana. Thesis, Indiana University.
3. Humbles, Jack. Symplocarpus.
4. Markle, Corrolle A. Flora of Wayne County, Indiana, continued.

Annelida:
1. Goodnight, Clarence J. Continued Work on the Opilionids and Oligochaetes.
2. Joyner, James W. Earthworms of the Upper Whitewater Valley (East Central Indiana.)

Crustacea:
Eberly, William R. Crustacea of Indiana, Particularly Wabash County, but Plankton Crustacea from Other Locations.

Insecta:
1. Siverly. Distributional and Ecological Studies of Mosquitoes of Delaware County, Indiana.
2. Wallace, Herbert S. Revision of the Genus **Hesperotettix**.
3. Ward, Gertrude L. Insects of the Upper Whitewater Valley (East Central Indiana).
4. Young, Frank N. Water Beetles as Indicators of Pollution. Taxonomic Studies of Genus **Peltodytes.**

Amphibia:
1. Gordon, Robert E. Competition Among Larval Ambystomid Salamanders.
2. Gordon, Robert E. Population Dynamics of Ambystoma.
3. List, James C. Establishment of a Reference Collection of Indiana Amphibians and Reptiles.

Reptilia:
Williams, Eliot C., Jr. Studies on the Population of the Box Turtle, **Terrapene carolina** (L.) and Small Mammals in the Allee Memorial Woods along Sugar Creek, Indiana.

Aves:
1. Cope, James B. Birds of Indiana.
2. Gough, Betty Jane. Breeding Bird Census—Mixed Deciduous Forest on Hanover College Campus, Indiana.
3. Hodson, Margaret. Birds of Grant County, Indiana.
4. Kirkpatrick, Ralph D. The Coturnix Quail in Indiana. Final Report P-R, Project Z-R, Indiana Department of Conservation.
5. Webster, J. Dan, and Betty Jane Gough. Breeding Bird Census—Beech-Maple Forest at Mary Gray Bird Sanctuary, Connersville, Indiana.

Mammalia:
1. Cope, James B. Bats of Indiana.
2. Kirkpatrick, Ralph D. The San Juan Rabbit, **Oryctolagus cuniculus**, in Indiana. Final Report, P-R, Project Z-R, Indiana Department of Conservation.

Miscellaneous Plant and Animal Groups:
1. Dineen, Clarence R. Bottom Organisms and Bottom Types of Saint Joseph River Drainage System of Indiana.
2. Laubengayer, Richard A. Inventory of Plant and Animal Groups in the Allee Memorial Woods Along Sugar Creek, Indiana.

Library Committee—Nelle M. Coats: As will be reflected in the treasurer's report, records have been searched and orders placed for items lacking from serial files. Volumes have been prepared for binding, both expenditures provided for by the Lilly Endowment, Incorporated gift. Additional binding provided for in the Academy's general budget has also been prepared. Also to be reported by the treasurer is Mrs. J. S. Wright's gift of $500.00 to the Library in honor of her husband's birthday, October 17. Mr. Wright had been chairman of a committee which in 1907 entered into a contract with the Indiana State Library, placing the Academy Library in its care and thus making its materials more widely useful. For this 75th anniversary a revision of the publication Periodicals currently received by the Library has been compiled and is being distributed to members at this session, courtesy of the State Library. Fifty-five new titles have been added during the year. An exhibit of some of these and other titles will be on view here tomorrow. Material from the library is constantly on display in the entrance hall of the State Library. Resources of the library were included in a discussion of the availability of science materials at a western Indiana librarians' conference last April. The Proceedings, vol. 68, 1958, published September 20, 1959, have been distributed, labor and wrappings, as usual, supplied by the State Library. The Torrey Bulletin has been added to the list of publications abstracting or indexing the Proceedings, making fourteen in all now.

Membership Committee—Robert I. Fletcher: Forty-four new membership applications for the Senior Academy and two for the Junior Academy were presented to the Academy for action during the last year. New application forms were printed carrying information as to the activities of the Academy and an application form to be completed and returned to the proper officers. It is recommended that all of the old forms be destroyed and only the new forms be used. The old forms carry the old dues charge and many have not been changed by hand, thus leading to problems for the Treasurer.

Program Committee—William H. Bessey: The report of the Program Committee is in essence the printed program which by now is available to everyone. Charles Heiser was responsible for the very successful spring meeting. Mr. Goethe sent the chairman a check for ten lunches and ten dinners for the fall meeting. After consultation with the President, the Secretary and a number of others, nineteen of the meals were offered to various members of the Academy with the request that if they were not going to be used, the Chairman should be informed immediately so that they could be offered to someone else. No refusals have been received to date. As of 8:00 a. m. this morning, reservations for lunch are down quite a bit from last year, but reservations for dinner are up. It is not clear as yet how many lunch tickets will be available on Friday.

Junior Academy—Howard H. Michaud: The twenty-sixth annual meeting of the Indiana Junior Academy of Science was held Saturday, November 8, 1958 at Marian College, Indianapolis. Four hundred and seventeen students, teachers, and guests registered for the 1958 annual meeting. This represented the largest attendance of any previous meeting

of the Junior Academy. The morning program included fifteen exhibits in science by high school students and career conferences in science and mathematics. Sixteen papers were read by Junior Academy members during the afternoon session including nine in the biological sciences and seven in the physical sciences. There are currently fifty-five Junior Academy of Science clubs on our roll. About sixty per cent of these are known to be quite active. Three new clubs were added since last year. They include the Science Club, Columbus High School, Columbus; the Science Club, Westlane Junior High School, Indianapolis; and the Heterogeneous Genius Club, Immaculate Conception Academy, Oldenburg. The twenty-seventh annual meeting of the Junior Academy will convene Saturday, October 31, 1959. Seventeen papers will be read by members of the Junior Academy including ten in the biological and seven in the physical sciences. The American Society of Bacteriologists will offer a cash award of $25.00 again this year to the student presenting the best paper on bacteriology or microbiology. The Kroger Grocery Company will again present a top award of $50.00 and a plaque and two runner-up awards of $25.00 each and plaques to the schools showing evidence of the best school science programs. Last year's top award winner was Shortridge High School, Indianapolis. The two runner-up winners were Howe High School, Indianapolis, and the University High School, Bloomington. This year's winners have been selected, and the awards will be presented to the schools on Saturday by Mr. Harry McDaniel, Indianapolis Kroger Division. Since reporting to the Executive Committee last year, the Indiana Academy of Science has received a grant from the National Science Foundation for a Visiting Scientists' Program for Indiana High Schools. Approximately eighty scientists from Indiana colleges and universities have agreed to participate in the program. Their names have been listed in a brochure that explains the program and that has been mailed to all Indiana high schools and teachers of science and mathematics. The Junior Academy is continuing its cooperation with the Regional Science Fairs, the state and national Science Talent Searches, and with Science Clubs of America.

Indiana Science Talent Search—R. W. Lefler: One hundred forty-two Indiana high school seniors completed entry requirements for the 12th Indiana Science Talent Search. Of this group 28 were designated finalists. The finalists and their sponsoring teachers were invited to the Junior Scientists' Assembly in Indianapolis, March 20-21, 1959. Fifteen of the finalists were declared winners in the search and recognized at the annual Honors Luncheon on Saturday, March 21. Of the papers submitted by the finalists, 39 per cent were related to the biological sciences, 16 per cent to mathematics, 4 per cent to earth science, 10 per cent to chemistry, and 31 per cent to physics. One hundred thirteen of the participating students responded to a questionnaire sent them in June. Of these, 109 indicated they had enrolled in a college, 83 in Indiana schools and 26 in out-of-state schools. In addition, 65 participants reported they had been awarded scholarships with stipends totaling more than $60,000.00. Thirty-three of the participants anticipate careers in engineering, 30 in physics or chemistry, 16 in biological sciences or medicine, 9 in mathematics, and 25 in other fields. In a special presentation at the Honors Luncheon the following

teachers received certificates in recognition of their sponsorship of 10 students who were designated finalists through the 12 years of the Indiana Science Talent Search: Woodrow Pemberton, Evansville Bosse High School; Walter Reed, Connersville Senior High School; L. A. Lundgren, Hammond High School; and E. Wayne Gross (posthumously), University School, Bloomington. The Junior Scientists' Assembly for the 13th Indiana Science Talent Search will be held on March 18-19, 1960. There was a deficit of $97.07 for the Indiana Regional Science Fairs. The balance for the Indiana Science Talent Search account is $1,263.87. Following this report a discussion of the finances of the Talent Search resulted in a motion that a recommendation be forwarded to the Budget Committee suggesting that they appropriate $200.00 to the Indiana Science Talent Search Fund.

Science Education Committee—Paul Klinge: The agenda items and items of discussion at the committee meeting, November 7, 1958, were as follows:

1. Duties of the Committee: Science Fairs, Science Talent Search, and Junior Academy are not within its jurisdiction.
2. Assistance can be rendered Science Fairs in following ways:
   a. help in raising money
   b. booklet for students interested in project work
   c. slides to illustrate project work
   d. money for project supplies
3. Work with State Department of Public Instruction in re-evaluating State certification requirements.
4. Committee could coordinate youth activities of Academy.
   a. Seek and administer funds.
   b. Prevent duplication of efforts of programs.
5. Money should be sought for following (possibly from NSF grant to Academy):
   a. administrative expenses
   b. awards
   c. participant expenses
   d. travel of high school students to universities for consultation
   e. tours of science clubs to university and industrial laboratories
   f. preparation of slides to help in project promotion
   g. project equipment support
   h. booklet of aids for projects
   i. committee meeting expenses
6. Recommend each section consider sponsorship of joint symposia with invited high school teachers on:
   a. graduate education of high school teachers
   b. how to teach science methods courses

It was suggested and taken by consent that the Science Education Committee undertake a study of the whole youth program of the Academy.

Bonding of Trustees—Scott McCoy: The Trustees of The Indiana Academy are duly bonded. This bond was renewed this October 1959 and covers a period of three years from November 18, 1959 to November 18, 1962 at a cost of $62.50 for the three years. The Hartford A. & I. with Gregory & Appel, Inc., Indianapolis, Indiana.

Indiana School and College Committee on Mathematics—G. N. Wollan: The I. S. & C. C. M. met on six occasions last year and has held one meeting so far this fall. Sub-committees have conducted surveys to get information about the mathematical training of mathematics teachers in junior and senior high schools of the state and of elementary school teachers, and to get information about mathematics taught in the schools at the various grade levels. These surveys have tended to support the conclusion that significant improvement ought to be possible. As specific activities designed to contribute to improvement, the I. S. & C. C. M. has:

1. urged Indiana colleges and universities to submit proposals to NSF for summer institutes and academic year in-service institutes for Indiana mathematics teachers and,

2. persuaded some of its members to organize evening meetings during the school year to which school mathematics teachers from the region around a college are invited to participate in discussions of mathematical topics. Such meetings were held last year at Butler University, DePauw University, Earlham College, Evansville College, Hanover College, Purdue University, Rose Polytechnical Institute, Fort Wayne, and Notre Dame University. The I. S. & C. C. M. is also a committee of the Indiana Council of Teachers of Mathematics and of the Indiana Section of the Mathematical Association of America. This year in an effort to provide a more effective base for the regional evening meetings, it is planned that local Councils of Teachers of Mathematics be organized at each of the places at which these meetings are held, to take over responsibility for the meetings. Dr. I. Owen Foster of the State Department of Public Instruction attended several I. S. & C. C. M. meetings, and a sound basis for co-operation with that department has been established. In order to expand these activities, the Academy submitted to NSF a proposal for a grant to provide needed funds. In any event we recommend that the committee be continued on the basis that its activities are of some value in promoting a worthy cause. It was recommended and taken by consent that the committee be continued for another year.

Relation of the Academy to State—W. A. Daily and F. Wallace: The Indiana State Legislature has appropriated the sum of $4,000 per annum to publish the Academy Proceedings for the fiscal years 1959-1960 and 1960-1961.

The secretary read a letter from H. Batchelder of the Committee on Teacher Education and Professional Standards of the Indiana State Teachers Association explaining why a state-wide meeting as suggested in our resolution a year ago had not been held. The secretary also read the invitation of the American Society of Tropical Medicine and Hygiene to members of the Academy to attend meetings at the Claypool Hotel October 28 through 31, 1959.

After a discussion of the library funds it was moved and duly passed that authority be vested in the officers to approve necessary transfer of funds to the library account. It was moved and duly passed that Mr. R. W. Stark be made a life member of the Academy in view of his contribution of $100.00 to the Academy. It was moved and duly passed that the Budget Committee be asked to appropriate $85.00 for an adding machine for the Treasurer's office.

The secretary reminded all division chairmen to provide the names of their successors to the secretary.

A short discussion was held concerning professional certification of science teachers.

The meeting adjourned at 9:53 p. m.

Respectfully submitted,
HARRY E. CRULL, Secretary

FALL MEETING
GENERAL SESSION
FRIDAY, OCTOBER 30, 1959
9:00 A. M.

The regular annual meeting of the Indiana Academy of Science was held in Room 162, Jordan Hall, Butler University, at 9:00 a. m. Friday, October 30, 1959. Vice-President George Diener of Butler University welcomed the Academy to the campus. The minutes of the Executive Committee meeting of Thursday, October 29, were read by the secretary and approved as read. The Necrologist, Dr. Will E. Edington, read the list of the following thirteen members who have died since the last annual meeting:

1. Jacob A. Badertscher
2. Pearl Harvey Brewer
3. Adam Hastings Fiske
4. Elmo Wayne Gross
5. Robert Earl Martin
6. Karl Wilhelm Meissner
7. Thomas Benjamin Noble
8. William Emil Riecken
9. Arthur Rosenthal
10. William Henry Shideler
11. Ralph W. Showalter
12. Ralph Bushnell Stone
13. Agnes Ermina Wells

Dr. Yuncker moved and it was seconded and passed that the Academy instruct the secretary to send a letter of best wishes and heartiest greetings to Mr. and Mrs. F. N. Wallace from the Academy. The meeting was adjourned and section meetings followed.

Respectfully submitted,
HARRY E. CRULL, Secretary

FALL MEETING

DINNER MEETING

FRIDAY, OCTOBER 30, 1959

The meeting was held in the main cafeteria of the Atherton Center. Dr. A. T. Guard, Vice-President of the Academy, presided. He introduced the guests at the speaker's table, including Dr. Theodore M. Sperry, President of the Kansas Academy and member of this Academy. The Nominating Committee reported and it was duly moved and passed that the recommendations of the Nominating Committee be accepted and the secretary instructed to cast a unanimous ballot for the officers. They are as follows:

President—A. T. Guard, Purdue University
Vice President—Lawrence H. Baldinger, Notre Dame
Secretary—William W. Bloom, Valparaiso University
Treasurer—Donald J. Cook, DePauw University
Editor—Richard A. Laubengayer, Wabash College
Press Secretary—Eugene Weinberg, Indiana University
Trustee of the Academy—Ward Rice, Eli Lilly

Names of Chairmen elected by the various sections were read. They are as follows:

Anthropology—M. S. Wadia
Bacteriology—Walter A. Zygmunt
Botany—S. N. Postlethwait
Chemistry—H. Burkett
Entomology—R. E. Niswander
Geology and Geography—J. C. Hook
History of Science—Mrs. Fay K. Daily
Mathematics—Kermit Carlson
Physics—C. S. Morris
Plant Taxonomy—William A. Daily
Psychology—R. Bollinger
Soil Science—Stanley Barber
Zoology—Carl Krekeler

Dr. A. H. Meyer of Valparaiso University announced that the fall meeting of 1960 would be held at Manchester College, North Manchester, Indiana.

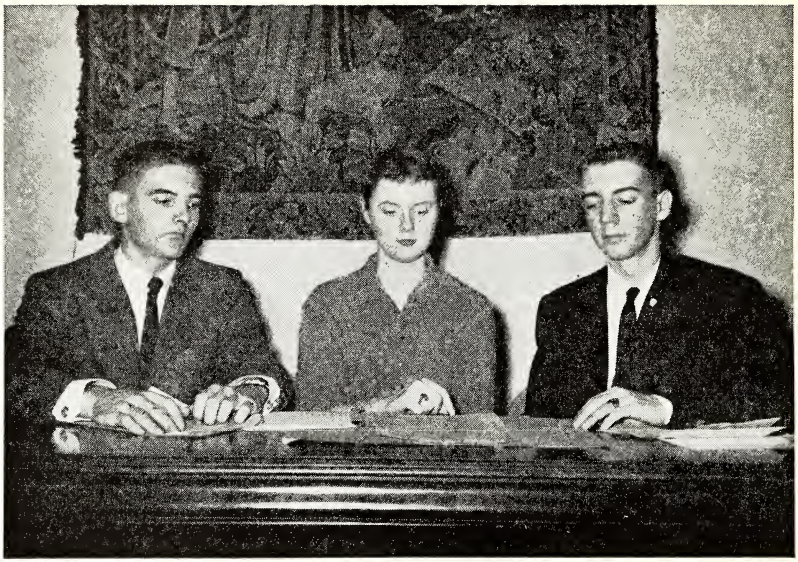
Dr. R. E. Cleland, retiring President, delivered the presidential address—"A Case History of Evolution." The meeting was adjourned.

Respectfully submitted,

HARRY E. CRULL, Secretary

NEW MEMBERS

Aughenbaugh, Nolan B., R. R. 10, Lafayette, Ind.	G
Campau, Dr. Edward J., 114 Willow Road, Greenfield, Ind.	E
Crum, Richard Owen, Tangier, Ind.	E
Decatur, David R., 159 N. Whitcomb, Indianapolis, Ind.	Z
Dobson, Dr. R. C., Dept. of Entomology, Purdue Univ., Lafayette, Ind.	E
Dowds, Richard E., 5015 N. Kenmore Rd., Indianapolis, Ind.	M
Engelhardt, Donald W., 406 N. Fess, Bloomington, Ind.	Bo
Faulkner, Charles H., Hawks Lake, Culver, Ind.	A
Fedynskyj, Mrs. Natalie, St. Mary's College, Notre Dame, Ind.	A
Fetters, Thomas W., 406 N. Fess, Bloomington, Ind.	Bo
Fogg, George, 114 W. College, Crawfordsville, Ind.	Bo
Frieders, Rev. Fabian, St. Meinrad College, St. Meinrad, Ind.	Z
Grothaus, Roger Harry, 120-14 Marshall Dr., West Lafayette, Ind.	E
Hardwick, Capt. Willard Eli, Dept. of Bacteriology, Indiana Univ., Bloomington, Ind.	Ba
Hartsock, James G., Agricultural Engineering Dept., Purdue Univ., Lafayette, Ind.	E
Hazeltine, William E., Dept. of Entomology, Purdue Univ., Lafayette, Ind.	E
Hindel, Rev. Richard, St. Meinrad College, St. Meinrad, Ind.	Z
Hummel, Arleen K., 4001 S. Otterbein Ave., Indianapolis 27, Ind.	Z, Ps
Johnston, Ernest R., Purdue Univ. Center, Indianapolis, Ind.	M
Kirkpatrick, Ralph D., Taylor Univ., Upland, Ind.	Z
Leoschke, William L., Chemistry Dept., Valparaiso Univ., Valparaiso, Ind.	C
Lubin, Dr. Bernard, Dept. of Psychiatry, Indiana Univ. Med. Center, Indianapolis, Ind.	Ps
McManus, Michael L., 116-9 Nimitz Dr., West Lafayette, Ind.	E
Matthews, Jr., David L., Dept. of Entomology, Purdue Univ., Lafayette, Ind.	E
Morrison, Frederick D., 847 Maple Dr., Greenfield, Ind.	E
Munsee, Jack R., Ind. State Teachers College, Terre Haute, Ind.	Z
Novak, Joseph D., Biology Dept., Purdue Univ., Lafayette, Ind.	Bo
Parrott, William L., Entomology Dept., Purdue Univ., Lafayette, Ind.	E
Patrick, Rose E., Indiana Central College, Indianapolis 27, Ind.	Z
Raibourn, Downey, 4114 Homerlee Ave., East Chicago, Ind.	A
Schmelz, Rev. Damian, St. Meinrad College, St. Meinrad, Ind.	Bo
Simpers, Robert E., R. F. D. 3, c/o Glen Fruin, Crawfordsville, Ind.	Bo
Smith, Earl C., 35 S. 24th St., Terre Haute, Ind.	C
Sprague, Newton G., 3510 Winthrop Ave., Indianapolis 5, Ind.	Ph, C
Thomas, Jr., Clarence, 5730 E. Washington St., #4, Indianapolis 19, Ind.	Bo
Tovazzi, Gino, Villa Concordia, Mira, Venezia, Italy	C
Westing, Arthur H., Dept. of Forestry and Conservation, Purdue Univ., Lafayette, Ind.	Bo
Winslow, Donald R., 2627 Dekist St., Bloomington, Ind.	Z
Yendol, William George, 128-11 Marshall Dr., West Lafayette, Ind.	E



Officers of the Junior Academy: l. to rt., Vice-President, Sheldon McCullum, Our Lady of Providence High School, Clarksville; Secretary, Nancy Davis, Shawe Memorial High School, Madison; President, William Schall, Central Junior-Senior High School, South Bend.

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1959

President: WILLIAM SCHALL, Central Junior-Senior High School, South Bend.

Vice-President: SHELDON MCCULLUM, Our Lady of Providence High School, Clarksville.

Secretary: NANCY DAVIS, Shawe Memorial High School, Madison.

Members of the Council: Mrs. Mary Gough, New Castle (1955-1959); Ernest Litweiler, South Bend (1956-1960); Mrs. Elizabeth Crider, Indianapolis (1957-1961); Robert Weber, Fort Wayne (1958-1962); Sister Suzanne, Vincennes (1959-1963); V. C. Cripe, South Bend (1960-1964).

PROGRAM OF THE TWENTY-SEVENTH ANNUAL MEETING

OCTOBER 31, 1959

Jordan Hall, Butler University, Indianapolis, Indiana.

8:30-9:30 a. m. Registration and Placement of Exhibits, Room 326.

10:00-11:00 a. m. Conferences in Science and Mathematics by faculty representatives of Butler University.

11:00-12 noon. Visits to Instructional Facilities and Laboratories of Butler University.

12:00 noon. Luncheon at the cafeteria.

1:00-2:00 p. m. Business meeting. Election of Officers and Presentation of the Kroger Awards, Cafeteria.

2:00-4:00 p. m. The Assembly Program.

I. Biological Science Section, Jordan Hall, Room 131.

II. Physical Science Section, Chapel, Christian Theological Seminary.

Papers: Biological Science Section, Sheldon McCullum presiding.

1. Is Escherichia Coli Found in the Final Effluent of the South Bend Sewage Treatment Plant? Shirley Marko, Walton Club, Adams High School, South Bend.
2. Bacterial Study of Milk, Nelda Arvin and James Aikman, Aquinas Science Club, Washington Catholic High School, Washington.
3. Effect of Vibrations on Serratia Marcescens Streaked on Nutrient Agar, Janice Shoemaker, Walton Club, Adams High School, South Bend.

THE CIRCULATORY SYSTEM
REACTION OF CARBON MONOXIDE IN THE BLOOD!
CARBON MONOXIDE IS POISONOUS BECAUSE IT UNITES VERY READILY WITH HEMOGLOBIN WHICH IS THE RED SUBSTANCE THAT SERVES AS AN OXYGEN CARRIER IF THE HEMOGLOBIN UNITES WITH CARBON MONOXIDE, IT IS NOT AVAILABLE FOR CARRYING OXYGEN. WHEN C.O HAS BEEN BREATHED THE PERSON COLLAPSES BECAUSE OF OXYGEN STARVATION. BLOOD TRANSFUSIONS WHICH SUPPLY FRESH HEMOGLOBIN IN THE VEINS OF THE PATIENT MAY HELP VICTIMS WHO HAVE BEEN KILLED BY C.O. REVEAL A PECULIAR RED COLOR IN THEIR BLOOD.
THE BLOOD VASCULAR SYSTEM!

A Student Exhibit on "Reaction of Carbon Monoxide on the Blood" from Ladywood School, Indianapolis.

4. Struggle for Existence Among Soil Mico-organisms, Marilyn Wichman, Aquinas Science Club, Washington Catholic High School, Washington.
5. Are Antibiotics Conquering Bacteria? Patricia A. Coleman, Science Club, Washington High School, Indianapolis.
6. Camouflage—A Necessity for Survival, Diane Osting, Science Club, Washington High School, Indianapolis.
7. Identity of Protoplast-infecting and Cell-infecting Particles Derived from T2 Bacteriophage, Norman Pace, Edinburg High School, Edinburg (illustrated).
8. The Effects of Temperature on the Respiration Rate of Goldfish, Mary Kathryn Crider, Westlane Junior High School, Indianapolis.
9. My Ant Colony, Pat Martin, Biology Club, Lew Wallace High School, Gary.
10. Effect of Bacteria on Plant Structures, Ivan Joe Brown, Junior Explorers of Science, Lebanon High School, Lebanon.

Papers: Physical Science Section, William Schall, presiding.

1. The Van de Graff Generator, Phy-Chem Club, Our Lady of Providence High School, Clarksville.
2. Refraction of Light Through Prisms, Phy-Chem Club, Our Lady of Providence High School, Clarksville.
3. Astronomical Observations and Calculations of an Asteroid, Terence Hooten, Aquinas Science Club, Washington Catholic High School, Washington.
4. Remanent Spin Magnetometer, William D. Schall, JETS, Central High School, South Bend.
5. Chemical Bonding in Allotropy, John Linsky, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne.
6. The Preparation of Acetamides from Primary and Secondary Amines, Samuel B. Etienne, Danville High School, Danville.
7. Construction and Possible Use of an Electrostatic Proton Accelerator as a Research Tool, Michael R. Meadows, Science Club, Senior High School, Richmond.

MINUTES

The twenty-seventh annual meeting of the Indiana Junior Academy of Science was held Saturday, October 31, 1959, in Jordan Hall of Butler University, Indianapolis, Indiana.

Eighteen exhibits of science projects by high school students were displayed in Room 326, Jordan Hall. The exhibits included the following: A Study of Mezium Americanum; Camouflage, A Necessity for Survival; Chemical Bonding in Allotropy; Effect of Bacteria on Stem Tissue; Entomology; Is Escherichia Coli Found in the Final Effluent of the South Bend Sewage Plant?; Light Beam Modulation; Plastic-Phenol Formaldehyde; Priz-Mir-Scope; Reaction of Carbon Monoxide on the Blood; Rocks;

Struggle for Existence Among Soil Micro-organisms; Textiles and Dyeing; The Effects of Temperature on the Respiration Rate of Goldfish; The Effects of Vibration on Serratia Marcescens; Van de Graff Generator; Wireless Broadcaster and Amplifier; and Your Wonder Drugs at Work (Are Antibiotics Conquering Bacteria?).

Conferences in science and mathematics were held at 10:00 a. m. by members of the faculty at Butler University. The science areas represented included botany, chemistry, mathematics, pharmacy, physics, psychology, and zoology. The cooperation of the Butler University faculty in this program was greatly appreciated by club sponsors and members of the Junior Academy.

Members of the staff who presented the separate science conferences also conducted tours through the instructional facilities and science laboratories of the University.

The annual business meeting was held in the cafeteria immediately following the noon luncheon. President William Schall, Central Junior-Senior High School, South Bend, introduced Vice-President Sheldon McCullum, Our Lady of Providence High School, Clarksville, and Secretary Nancy Davis, Shawe Memorial High School, Madison.

President Schall then called upon Dr. Alexander E. Jones, Dean, College of Arts and Sciences, Butler University, to welcome the Junior Academy on the occasion of their annual meeting. Dean Jones encouraged the students to continue their interest in science and all phases of education leading toward a productive career.

Mr. William Tatter, Indianapolis Kroger Division, was introduced next to present the second annual Kroger awards. Mr. Tatter expressed briefly Kroger's interest in encouraging good high school science programs. A top award of fifty dollars and a plaque were presented to Washington High School, Indianapolis. Two runner-up awards of twenty-five dollars and a plaque were presented to both Garfield High School, Terre Haute, and to Washington Catholic High School, Washington.

The next item of the business meeting was the election of officers. The list of nominees was submitted by the Council from names received from club sponsors and nominations were accepted also from the floor. The following officers were elected for 1960: president, Harry Scribner, New Albany High School, New Albany; vice-president, Robert Raymond, Central Junior-Senior High School, South Bend; secretary, Ann Burton, University High School, Bloomington.

Mr. Ernest Litweiler, reporting for the Council, announced that Sister Suzanne, sponsor of the Sigma Tau Science Club, Saint Rose Academy, Vincennes, was named to fill the unexpired term of Sister Mary Blanche of Washington Catholic High School, Washington, since the latter had moved to Washington, D. C. Mr. V. C. Cripe, sponsor of the JETS Science Club, Central Junior-Senior High School, South Bend, was named the new Council member replacing Mrs. Mary Gough, New Castle, whose term expired this year.

Awards for the "best boy" and "best girl" in science were received by William D. Schall, Central Junior-Senior High School, South Bend, and Patricia Coleman, Washington High School, Indianapolis, respectively. A certificate of merit was presented to each, together with a year's mem-

bership in the American Association for the Advancement of Science. Terence Hooten, Washington Catholic High School, Washington, and Nancy Davis, Shawe Memorial High School, Madison, received honorable mention.

Professor H. H. Michaud, State Sponsor, Purdue University, expressed appreciation on behalf of the Junior Academy of Science for the splendid cooperation of Butler University for providing the facilities for the meeting. Dr. William H. Bessey, Department of Physics, Butler University, was introduced and commended for his special efforts as local program chairman in making the program a success. Professor Michaud announced that the 1960 annual fall meeting will be held at Manchester College.

Thanks was expressed to Miss Jerry Motley, Science Club Sponsor, Howe High School, Indianapolis, for her work as editor of the Junior Academy Journal. Both the spring and fall issues were given to members at the registration table.

Miss Marilyn Wichman, Aquinas Science Club, Washington Catholic High School, Washington, received an award of twenty-five dollars for the best exhibit on bacteriology. The title of the exhibit was "Struggle for Existence Among Soil Micro-organisms." Patricia Coleman, Washington High School, Indianapolis, received honorable mention for her exhibit on "Your Wonder Drugs at Work." An award of twenty-five dollars was presented to Mr. Norman Pace, Edinburg High School, Edinburg, for his paper on "Identity of Protoplast-infecting and Cell-infecting Particles Derived from T2 Bacteriophage." Miss Shirley Marko, Adams High School, South Bend, received honorable mention for her paper "Is Escherichia Coli Found in the Final Effluent of the South Bend Sewage System?" These awards are presented each year by the American Society of Bacteriologists.

A brief account of the papers presented to the biological science section follows:

Shirley Marko, Walton Club, Adams High School, South Bend, discussed the question, "Is Escherichia Coli Found in the Final Effluent of the South Bend Sewage System?" The purpose of the experiment was to determine whether the final effluent of the South Bend Sewage Plant was safe for public use. Water samples which were collected from the water entering the plant and leaving it were tested. The tests proved that the treatment plant was 86% effective, which measures up to the United States Health Service requirement.

"A Bacterial Study of Milk" was reported by Nelda Arvin and James Aikman, Aquinas Science Club, Washington Catholic High School, Washington. Different methods of handling raw and pasteurized milk were employed to find what conditions were optimum for keeping the Coliform bacterial count low after it reaches the consumer. The conclusions were that only sanitary handling and refrigeration provided optimum conditions for keeping Coliform count low in milk after it reaches the consumer.

Janice Shoemaker, Walton Club, Adams High School, South Bend, related the results of her experiment on the "Effect of Vibrations on Serratia Marcescens Streaked on Nutrient Agar." Serratia marcescens, a bacillus form of bacteria, were streaked on nutrient agar in three sterile

petri dishes and kept at room temperatures. Two of the dishes were vibrated for different periods of time and her conclusions were that the bacteria grew best under conditions with no vibrations.

"Struggle for Existence Among Soil Micro-organisms" was the title of the next paper given by Marilyn Wichman, Aquinas Science Club, Washington Catholic High School, Washington. Antibiotic producing colonies of bacteria were found in collections of four different types of soil. These were cultivated in petri dishes and the experiment proved that the bacteria produced substances that inhibited growth of other micro-organisms. It was concluded that this provided more room for the chemical producing bacteria to grow.

A paper by Patricia A. Coleman, Science Club, Washington High School, Indianapolis, on "Are Antibiotics Conquering Bacteria?" explained that her experiment was an attempt to determine whether certain antibiotics were really effective against specific bacteria. Various antibiotics were introduced into pure cultures of harmful bacteria. While the antibiotics used were found to be effective, it was concluded that they should be administered only by a physician because of possible harmful side-effects such as hives, intestinal disturbances and allergies.

"Camouflage—A Necessity for Survival" was the topic presented by Diane Osting, Science Club, Washington High School, Indianapolis. Sunfish and catfish were found to be able to change color in adaptation to various colored backgrounds. This, she concluded, was an effective means of protecting the fish against its enemies and was important in its survival.

Ivan Joe Brown, Junior Explorers of Science, Lebanon High School, Lebanon, discussed "The Effect of Bacteria on Plant Structures." Bacteria growing on certain plant structures were found to be contagious and dangerous to other plants.

"Identity of Protoplast-infecting and Cell-infecting Particles Derived from T2 Bacteriophage" was the title of a paper presented by Norman Pace, Edinburg High School, Edinburg. The purpose of the experiment was to identify the agent derived from T2 bacteriophage responsible for bacterial cell infection.

The next paper on "The Effect of Temperature on the Respiration Rate of Goldfish" was read by Mary Katherine Crider, Westlane Junior High School, Indianapolis. A graph was used to show that the respiration rate of the goldfish increased with higher temperature and decreased as the water temperature was lowered. It was also indicated that a range of 60° to 70° F. is the best temperature to maintain for the goldfish.

"My Ant Colony" was the final topic of the biology section discussed by Pat Martin, Biology Club, Lew Wallace High School, Gary. This represented a description of the activities, division of labor, and life history of an ant colony.

Anita Morris, Washington High School, Indianapolis, served as acting secretary of the biological science section.

The following is a brief account of the papers read at the physical science section:

"The Van de Graff Generator" was the title of the paper given by Steve Ames, Phy-Chem Club, Our Lady of Providence High School, Clarksville. The Van de Graff generator was built in 1931 in order to accelerate

particles to strike a target. The report explained how the generator works and that it is used to change the atomic structure of the atom.

Steve Vince, Phy-Chem Club, Our Lady of Providence High School, Clarksville, discussed the "Refraction of Light Through Prisms." With the aid of diagrams, it was pointed out that white light could first be broken into colored light and then back to white light again by the use of prisms.

The next paper on "Astronomical Observations and Calculations of an Asteroid" was read by Terence Hooten, Aquinas Science Club, Washington Catholic High School, Washington. He explained that the origin of these minor planets was unknown, although many theories exist. It is the special work of research to discover and determine the position of the asteroids by employing similar triangles and the medians of these triangles.

"Remanent Spin Magnetometer" was the topic presented by William Schall, JETS, Central Junior-Senior High School, South Bend. The theory, operation and design of the magnetometer were explained. Its use was to study paleo-magnetism—i.e., to locate the magnetic pole at the time when the earth's sediments were formed.

John Linsky, Albertus Magnus Science Club, Central Catholic High School, Fort Wayne, read a paper on "Chemical Bonding in Allotropy." Allotropy was explained as the phenomenon of the existence of an element, or sometimes a compound, in two or more different forms. Thus the diamond and graphite are two allotropic forms of carbon. Models were displayed to show the different types of bonding and it was explained that high temperatures and pressures would change graphite to an artificial diamond. The diamond can be reduced to graphite by subjecting it to high temperatures and low pressure, thus making the transition cycle interchangeable. The two main allotropic forms of phosphorus, red and white, were also discussed.

Michael R. Meadows, Science Club, Senior High School, Richmond, explained "The Construction and Possible Use of an Electrostatic Proton Accelerator as a Research Tool." The electrostatic accelerator functions on the principle that like electrical charges repel each other. A large positive potential is maintained by a Van de Graff generator and a source of protons is provided by a local beam of electrons at 500 w. passing through a volume of hydrogen gas. The protons are then repelled and accelerated down the six foot accelerator tube. The air in the tube has been pumped out to provide a free path for the protons. At the opposite end of the tube is the target chamber. The targets, mostly thin foils, are placed in the chamber. The kinetic energy of the protons, due to the acceleration, is equal to the potential difference between the two ends of the acceleration tube.

The final paper entitled, "The Preparation of Acetamides from Primary and Secondary Amines," was presented by Samuel B. Etienne, Danville High School, Danville. The purpose of the experiment was an attempt to prove that the same acetamide derivatives could be produced from Schiff's bases, in a one step process, by reacting them with trimethylamine borane in glacial acetic acid, as could be produced from the Schiff's bases, in a two-step process, by treating them with dimethylamine borane in glacial acetic acid to yield secondary amines and then treating the second-

ary amines with either acetic anhydride or acetyl chloride to produce the acetamide derivatives. No specific conclusions were reached since further experimentation is needed to check the results.

The minutes of the physical science section were recorded by Nancy Davis, Secretary, Junior Academy, Shawe Memorial High School, Madison.

The twenty-seventh annual meeting of the Junior Academy of Science was attended by four hundred and thirty-seven registered members, sponsors and guests. This is the highest attendance ever recorded at an annual meeting and attests to the growing interest and improved quality of the Junior Academy program.

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

FALL 1959

Town	*School and Club*	*Sponsor*
Bloomington	H. S., National Scientific Honor Society (1931)	Merril L. Crisler
Bloomington	University H. S., Junior Academy (1938)	Donald R. Winslow
Chesterton	H. S., Science (1954)	Robert McCord
Clarksville	Our Lady of Providence H. S., Phy-Chem (1956)	Sister Joseph Louise
Clayton	H. S., Junior Academy (1951)	Howard C. Lewis
Columbus	H. S., Science (1958)	Lawrence Poorman Neal Carmichael
Crawfordsville	H. S., Up-N-Atom (1950)	David Wells
Edinburg	H. S., The Alchemists (1954)	S. C. Harrell
Elkhart	H. S., Junior Academy (1940)	Robert Mahan
Evansville	Reitz Memorial H. S., Science (1958)	Sister Jean Margaret
Fort Wayne	Central H. S. (1940)	Iva Spangler
Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club (1952)	Sister Anne Pauline
Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
Fort Wayne	North Side H. S., Nature (1936)	Vesta Thompson
Fort Wayne	South Side H. S., Junior Academy of Science (1956)	Robert Weber
Gary	Edison H. S., Beaker Breakers (1949)	Mrs. Martha B. Connor
Gary	Lew Wallace H. S., Biology (1935)	Lola Lemon
Gary	Lew Wallace H. S., Klub Kem (1941)	Mrs. Helen McKenzie
Gary	Tolleston H. S., Biology (1952)	John Reidel
Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
Gas City	Mississinewa Joint H. S., Science (1936)	Roy McKee
Griffith	H. S., Science (1953)	George M. Bunce

Hamlet	H. S., Science (1954)	Lawrence Cushman
Hobart	H. S., Science (1952)	Lola Stewart
Indianapolis	Howe H. S., Science (1949)	Jerry Motley
Indianapolis	Ladywood School, Guerin Science Club (1957)	Sister Pauline Marie Sister Louise
Indianapolis	St. Agnes Academy, Science (1959)	Sister Amelia
Indianapolis	Shortridge H. S., Naturalist's Club (1947)	Robert A. Weaver
Indianapolis	Shortridge H. S., Science (1931)	Mrs. Henrietta A. Parker
Indianapolis	Technical H. S., Nature (1932)	Charles E. Russell
Indianapolis	Washington H. S., Science (1931)	Mrs. Elizabeth Crider
Indianapolis	Westlane Jr. H. S., Science (1959)	John W. Van Sickle
Jeffersonville	Clark and Floyd County Seminar (1959)	Harold E. Cook
LaPorte	H. S., Bi-Phi-Chem (1958)	Frances Gourley Byron Bernard
Lebanon	H. S., Jr. Explorers of Science (1953)	Helen E. Reed
Loogootee	St. John H. S., Science (1959)	Sister Mary Ellen
Madison	Shawe Memorial H. S., Science (1957)	Theodore A. Winkel
Mishawaka	H. S., Science (1936)	Darl F. Wood
New Albany	H. S., Science (1935)	Erwin Steinkamp
New Castle	H. S., Science (1947)	Betty Jo Montag
New Haven	H. S., Phi-Chi (1954)	Keith Hunnings
Oldenburg	Immaculate Conception Academy, Heterogeneous Genius Club (1958)	Sister Mary Constance
Richmond	H. S., Science (1950)	Von Alexander
Rossville	H. S., Science (1954)	Martin Silverthorn
Sanborn	H. S., Up and Atom (1954)	Paul D. Carter
South Bend	Central H. S., Jr. Academy (1939)	V. C. Cripe
South Bend	John Adams H. S., Adams Walton (1953)	Ernest Litweiler
Wanamaker	Franklin Twp. H. S., Sigma Mu (1958)	Jerry M. Colglazier
Vincennes	St. Rose Academy, Sigma Tau (1958)	Sister Suzanne
Washington	Catholic H. S., Aquinas Science Club (1958)	Sister Jean Francis

NECROLOGY

Will E. Edington, DePauw University

Jacob A. Badertscher

Bluffton, Ohio — Bloomington, Indiana
January 11, 1879 — March 12, 1959

During the period of 35 years from 1914 to 1949 more than four thousand students in the Medical School at Indiana University took courses in Histology and Neural Anatomy in preparing to become doctors, and their instructor in these vital courses was Jacob A. Badertscher. It is difficult to realize what a tremendous influence this one man has had on the lives of these future doctors and the tens of thousands of patients that came under their care.

Jacob A. Badertscher was born in Bluffton, Ohio, on January 11, 1879. After completing the usual public school courses he ultimately began his undergraduate work in Ohio University, Athens, Ohio, served as an assistant in biology in his senior year and as an instructor the following year, and received the Ph.B. degree in 1909 and the Ph.M. in 1910. That fall he was appointed assistant in histology and embryology at Cornell University and an instructor the following year. In 1914 he received the Ph.D. degree in those subjects. He immediately came to Indiana University as an instructor in Anatomy, was promoted to assistant professor the next year and to associate professor in 1917, and became Professor of Anatomy in 1921. He remained at Indiana until his retirement in 1949 as Professor Emeritus. He also served as Assistant to the Dean from 1940 until his retirement.

Dr. Badertscher was a perfectionist both as a teacher and a researcher. He was a kindly man, behind his back affectionately known as "Jakie" to his students, who recognized in him a great teacher who was personally and devotedly interested in their welfare and success. As a teacher he was very conscientious and demanded perfection in student performance and yet he was considered as eminently fair. At the time of his retirement he received hundreds of congratulatory letters from his former students and characteristically he wrote a note of thanks to each one of these hundreds of student well-wishers.

During his active years he carried on research in microscopic anatomy and published articles in the Proceedings of the Society of Experimental Biology and Medicine, American Journal of Anatomy, Anatomical Record, and Stain Technology. He was a "superb technician and a meticulous and accurate investigator" whose results could be and were accepted with complete confidence.

He was a member of the American Association of Anatomists. He joined the American Association for the Advancement of Science in 1917 and was made a Fellow in 1921. He became a member of the Indiana Academy of Science in 1914 and was elected a Fellow in 1917. He also held membership in Phi Beta Kappa, Sigma Xi, and Phi Chi medical

fraternity. He was listed in Who's Who in America and American Men of Science.

Dr. Badertscher lived a full life of service to humanity and passed away on March 12, 1959, at the age of 80, following a heart attack. The subtle but real influence of his work will continue indefinitely.

PEARL HARVEY BREWER

Upper Sandusky, Ohio — West Lafayette, Indiana
December 10, 1883 — December 8, 1958

Successful modern agriculture is largely applied chemistry. The soil is studied and treated to fit the plant. The plants and animals are studied for their environmental and growth characteristics and for the control of their diseases and the pests that prey on them. Agricultural chemistry and farm mechanization are basic in our economy and to the teachers and researchers in these subjects in our agricultural schools is due the credit for a significant part in the attainment of our high standard of living. Pearl Harvey Brewer as a teacher of agricultural chemistry for 34 years at Purdue University made a distinct contribution to agriculture in Indiana. While he regularly taught courses in general agricultural chemistry and advanced soil chemistry, his general interest was in the application of colloid chemistry to agriculture, a course he initiated in 1926 and taught every year until his retirement in 1954.

Professor Brewer came to Purdue in 1920 as an instructor in agricultural chemistry. Previously he had taught seven years as principal in Harrod and Magnolia High Schools in Ohio. Entering Defiance College he served as an instructor from 1917 to 1919 and received an A.B. degree in chemistry and mathematics in 1919. The next year he spent as a research chemist with the American Roller Mills. At Purdue, as time from his teaching would permit, he did graduate study and received the M.S. degree in 1931. He was promoted to assistant professor in 1933 and in 1934 he was transferred to the newly created Department of Agricultural Chemistry where he also taught courses in dairy chemistry and food analysis. In recognition of his long and faithful service to Purdue he was awarded at the time of his retirement, in 1954, the title of Professor Emeritus. Professor Brewer was an enthusiastic and stimulating teacher.

He joined the Indiana Academy of Science in 1921 but he had not been active in its work. He became a member and a Fellow of the American Association for the Advancement of Science in 1934 and he was also a member of the American Chemical Society. His research interests were in the virus diseases of plants and animals and he also did some work in the purification of soybean oil. He was listed in American Men of Science.

Professor Brewer was active in civic and church work, being a member of the Exchange Club for a number of years and a member of the Official Board of the First Christian Church in Lafayette. An ardent Mason, he was active in the Eastern Star, the Lafayette Commandery and the Knights Templars. In his earlier years he was an enthusiastic golfer and he maintained a cottage on Lake Freeman where he enjoyed fishing and boating. He was also interested in his farm near Lima, Ohio.

Pearl Harvey Brewer was born on December 10, 1883, in Upper Sandusky, Ohio, and he died on December 8, 1958, in his home in West Lafa-

yette, Indiana, following a heart attack, just two days before his seventy-fifth birthday.

ADAM HASTINGS FISKE

Wrightsville, Pennsylvania — Woodside, California
September 27, 1894 — August 25, 1959

Fate was unkind to Adam Hastings Fiske. Apparently in excellent health, he had retired on April 30, 1959, as a vice-president of Eli Lilly & Company, after 40 years of distinguished service, and had moved from Indianapolis to a new home in Woodside, California, near San Francisco, with every expectation of enjoying a few years of leisure. He died of a heart attack on August 25, 1959, while on a fishing trip.

Dr. Fiske was born on September 27, 1894, in Wrightsville, Pennsylvania, and received his public school education there. After graduating from high school he entered the Philadelphia College of Pharmacy and Science and received a degree in pharmacy in 1916. He remained at the college the next year as an instructor and then entered the Army and served as a second lieutenant and pilot in the Air Service from 1917 to 1919 in World War I. He joined Eli Lilly and Company in 1919.

His all-around ability and leadership qualities were early recognized and led to his appointment to positions of responsibility in widely varied phases of the company's operations. He had served as production superintendent, director of the control division, manager for seven years of the western division of the sales organization with headquarters in San Francisco, manager of domestic sales, executive director of the research and control division, and, in 1945, vice- president in charge of research, development and control. In 1947 he became a member of the Lilly Board of Directors and the Executive Committee. He relinquished his responsibilities in development and control in 1955 to become Lilly's international representative in developing and maintaining contacts with chemical and pharmaceutical manufacturers in Great Britain and Europe. In all his dealings with his fellow workers he was recognized as fair, considerate and loyal.

Dr. Fiske was a member of the board of the United States Committee of the World Medical Association and also a member of the board of trustees of the Health News Institute and he was its president the year preceding his death. He also held memberships in the American Association for the Advancement of Science, American Pharmaceutical Association, Association of Food and Drug Officials, American Institute of Management, New York Academy of Sciences, Indianapolis Chamber of Commerce, National Rifle Association, American Legion, Kappa Psi professional pharmacy fraternity, and the Service Club of Indianapolis. He was also a Mason. He joined the Indiana Academy of Science in 1946.

He served as a trustee of the Philadelphia College of Pharmacy and Science and in recognition of his distinguished service the College awarded him the honorary Doctor of Science degree in 1956. In 1958 the American Drug Manufacturers Association presented him with a resolution recognizing his service as president in 1954-55, vice-president for two years previously and member of its executive committee for eleven years. Dr. Fiske was listed in Who's Who in America.

Dr. Fiske was not known to many members of the Academy and it is to be regretted that the Academy as organized at present does not attract the active participation of the pharmaceutical chemists. However the Academy is proud of the service of Dr. Fiske and his interest in the Academy.

ELMO WAYNE GROSS

St. George, West Virginia — Bloomington, Indiana
March 31, 1916 — December 25, 1958

In the untimely death of Elmo Wayne Gross at the age of 42 Indiana lost one of its most progressive and successful science teachers. Since 1952 he had trained four finalists in the national Westinghouse Science Talent Search which gave the Indiana University High School the distinction of producing more finalists in this contest than any other Indiana high school. He was a master teacher in science, dedicated to his students, and possessed that ability to gain their complete confidence and to inspire them to achieve the maximum in their endeavors. He was also co-author with Ira C. Davis and John Burnett of three widely used textbooks in junior high school science. He was the physics editor of "School Science and Mathematics," monthly journal of the Central Association of Science and Mathematics Teachers, had served four years on the Association's Advisory Board, and at the time of his death he was chairman of its Policy and Resolutions Committee.

The son of a Methodist minister, he was born on March 31, 1916, in St. George, West Virginia. He graduated from Hopedale, Illinois, High School in 1934 and received both the bachelor's degree in 1940 and the master's degree in 1946 from the Illinois State Normal University. In 1946 he became a member of the Indiana University School of Education faculty as an instructor and critic teacher with physics as his particular interest. Later he was made chairman of the University High School science department. Before coming to Indiana he had taught six years in Illinois high schools, two years, 1940-42, at Straughn and four years, 1942-46, at Blue Mound. He had completed most of the requirements for the doctorate in Education at Indiana University before his death.

Mr. Gross was a member of the American Association for the Advancement of Science, National Association of Student Teachers, National Science Teachers Association, Indiana State Teachers Association, Bloomington Metropolitan Teachers Association, and Phi Delta Kappa national education fraternity. He joined the Indiana Academy of Science in 1947 and cooperated with the Academy in its Junior Academy work. One of his finalists in the Science Talent Search, Roger Cuffey, was president of the Junior Academy in 1956 and he and other finalists gave papers on the Junior Academy programs. In 1956 Mr. Gross founded the Summer Institute for High School Science Students on the campus at Indiana University. He was a member of the Masonic Lodge of Blue Mound, Illinois, and the Methodist Church.

He was interested in many things such as growing fine flowers and vegetables in his garden, raising chickens and turkeys for home use, working in his woodworking shop. He had just finished making a Nativity Scene for his yard a few days before his brief final illness and his death on Christmas Day, 1958.

He was happiest when he could help his students in science and advise them in choosing scientific careers and, following his death, he was paid many tributes by former students and parents of students. In his memory the E. Wayne Gross Science Scholarship Fund was established by his wife, Lucile C. Gross, whereby under the supervision of the Indiana University Foundation two $500 scholarships will be available annually to senior science students of the University High School. The Fund is financed through royalties from his textbooks and gifts of former students, colleagues and friends.

ROBERT EARL MARTIN

Monroe County, Indiana — Madison, Indiana
August 18, 1894 — June 27, 1959

When the history of Hanover College for the past thirty years is written describing Hanover's substantial growth and the expansion and development of its beautiful campus the names of two men will certainly stand out. They both came to Hanover in the same year and the earthly work of both ended within a two-year period. Hanover's great president, Albert G. Parker, arrived on the campus in August, 1929, and his first official act was to send a telegram to Robert Earl Martin asking him to be professor of physics. Dr. Martin accepted and arrived on the campus late in August. Dr. Parker, who proved to be a genius at raising money for Hanover College, came to Hanover after a distinguished educational career in China and Japan. Dr. Martin, a native Hoosier, returned to his home state after spending eleven years teaching physics in Lehigh University. Hanover College was destined to receive a complete physical rehabilitation and an educational quickening.

R. Earl Martin was born in Monroe County, Indiana, on August 18, 1894. Following his graduation from high school he met the Indiana teacher requirements and taught in the Monroe County schools from 1912 to 1915 and in Montmorenci, Indiana, High School the next year. He completed the work for the A.B. degree at Indiana University in 1917. After teaching one year in the Clayton, New Mexico, High School he accepted an instructorship in physics at Lehigh University in 1918 and was promoted to assistant professor in 1921. Eight years later he came to Hanover and remained there until his retirement in June, 1959. While he was at Lehigh he received its M.S. degree and in 1925 Indiana University conferred the Ph.D. in physics on him. Less than a month after his retirement he died in a Madison hospital on June 27, 1959, after a brief illness.

When Dr. Martin went to Hanover he found a college enrolling about 500 students, ill equipped in both buildings and laboratory facilities. He had spent the immediately preceding summer as an acoustical engineer with the American Telegraph and Telephone Company in New York City and at Hanover he found the physics department located in small quarters, the laboratory with meager equipment, and a physics enrollment of about twenty students. He vocally expressed his dissatisfaction with what he found wrong not only with his department but with other things around the college and finally accepted President Parker's challenge in the spring of 1930 to take over as manager and superintendent of buildings and

grounds without pay. For the next ten years he had oversight of all the improvements and maintenance on the campus in addition to teaching not less than 18 hours a semester. He received some compensation during the last three years of this service due to the improved financial condition of the college.

He surveyed and mapped the campus, supervised the bringing of 3,300 trees from Indianapolis to be planted on the campus, installed coal stokers in most of the buildings, replaced the 2 horsepower pump of the then existing college water system with two 40 horsepower and one 7½ horsepower pumps, used a WPA force of 100 students to grade the athletic field, build the track and fence in the field, laid walks on the campus, installed street lights and surveyed roads through the campus, and looked after the plumbing, heating, lighting, repairing and cleaning of the college buildings and faculty residences owned by the college. He was able to do this through the efforts of Dr. Parker in securing gifts of money to the college, in particular from the steel magnate, William H. Donner, who gave Hanover $20,000 in 1937 to be used in drawing up plans for the campus and followed this with challenge gifts of $250,000, $500,000 and $250,000, which were met by alumni, trustees and friends of the college.

He staked out the new buildings in 1945 and derived great pleasure in planning the layout for the physics department in the new science building, Goodrich Hall, completed in 1947, with two large laboratories, lecture room, library and office, workshop, three darkrooms, storage room and $30,000 worth of physics equipment not including war surplus supplies received by the college.

During twenty-eight of his thirty years at Hanover Dr. Martin taught all the physics and during the five World War II years he taught mathematics also. He was an excellent teacher who kept up to date and he taught with a realistic approach. He taught seven summers at the University of Louisville, one summer at the Indiana University Extension Center in Jeffersonville, and for seven years he was science-mathematics technician in ballistics at the Jefferson Proving Ground.

Dr. Martin was a member of the American Association for the Advancement of Science and the American Physical Society. For 20 years he was secretary of the Indiana State Physics Teachers Association and he served as its president for one year. He helped to organize chapters of Sigma Xi and Sigma Pi Sigma physics society at the University of Louisville, and he served for sixteen years as faculty adviser to Lambda Chi Alpha social fraternity at Hanover. He joined the Indiana Academy of Science in 1925 and was made a Fellow in 1947. He was active in Academy work, serving on various committees, and, at the time of his death, he was a member of the Junior Academy and Membership committees. He was Chairman of the Physics Section in 1941 and 1945. He did some research and presented the results to the Academy and he published several papers in the Proceedings.

An active worker and deacon for 17 years of the Hanover Presbyterian Church, he taught a Sunday School class for a number of years and also served for a time as superintendent. He was a 32° Mason and a past master of the Hanover Masonic Lodge and its secretary for eighteen years.

Dr. Martin lived an effective life of service to Hanover College and Indiana education, and the Academy has lost a most active, loyal and dependable member.

KARL WILHELM MEISSNER

Reutlingen, Germany — Died at sea
December 15, 1891 — April 13, 1959

Thirty years ago the United States was passing through one of the worst economic depressions in its history and before the next decade had passed Europe was experiencing political upheavals and World War II had begun. The rise to power in Germany of Adolph Hitler led to mass emigration as well as numerous emigrations of individuals who fled for safety or left because they could not accept the doctrines propagated by Hitler. Among these individuals were numerous scientists who came to the United States rather than submit to tyranny. Karl Wilhelm Meissner, Director of the Physics Department at the University of Frankfurt am Main, Germany, and one of the present century's outstanding scientists, refused to compromise the basic principles of democracy and human freedom and was dismissed by the Nazis in 1937. He came to the United States the next year as an assistant professor of physics in the Worcester Polytechnic Institute, Worcester, Massachusetts, remaining there three years. In 1941 he was invited by Dr. Lark-Horovitz to come to Purdue as visiting professor of physics. Following his naturalization in 1943 he was appointed to the permanent position of professor of physics in charge of the spectroscopic laboratory. He was already known internationally for his work when he came and he further enhanced his reputation by his discoveries while at Purdue. He was on sabbatical leave from Purdue and was returning to Europe to see his sister and to visit several scientific laboratories, present a paper at the International Symposium on Interferometry in June at Teddington, Middlesex, England, and spend the summer term at the University of Kiel, Germany, as visiting lecturer in spectroscopy, when he was stricken with a fatal heart attack on April 13, 1959, while at sea aboard the Cunard Liner, Ivernia.

Dr. Meissner was an experimental physicist with a wealth of creative ideas and deep insight into spectroscopic problems which enabled him to analyze a problem and attack it with keen confidence and skill that generally led to its solution. He was a master at unravelling the complexities of the rare gases. In 1935 he developed his own atomic beam method for studying hyperfine structure and with utmost patience, precision and ingenuity he utilized the interference methods for extremely accurate measurements of light waves. As a student in 1914 he was the first to prove experimentally the existence of oxygen on the sun and in 1933 he proved the same for sulfur. From 1942 on he was interested in developing the atomic beam light source to produce a primary standard of length and to solve problems related to the nuclear spin and magnetic moments. The property of perfect diamagnetism in metals at finite temperatures is known as the Meissner effect.

He was the author or joint author of more than 60 articles in American and German scientific journals on "the theory of optical instruments, the precision measurement of wave lengths, regularities in spectra, term

analysis of spectra, hyperfine structure, isotope shift, Stark and Zeeman Effect, lifetime measurements of metastable atomic states, and gaseous discharge phenomena." He also wrote book reviews and was author of a book on spectroscopy and did consulting and editorial work. Dr. Meissner was active in the Indiana Academy of Science, presenting the first of eight papers before the Physics Section in 1946 and the last in 1958. Six of these papers were joint reports and abstracts for all eight papers appear in the Proceedings of the Academy.

Dr. Meissner was born on December 15, 1891, in Reutlingen, Germany, and attended the schools there. In 1910 he began his studies in physics and mathematics at the University of Tuebingen and also did some work in the University of Munich in 1912 and received the doctorate in 1915 from Tuebingen. He worked under the internationally known physicists Paschen, Roentgen and Sommerfeld. Following a brief period as an instructor in the high school at Stuttgart, he became an assistant in the Department of Physics at the University of Zurich and was promoted to Privatdozent in 1919. He accepted an associate professorship in 1925 at the University of Frankfurt, was promoted to a professorship in 1928, and became Director of the Physics Department in 1931. Dismissed by the Nazis in 1937, he came to the United States in 1938.

Besides his memberships in foreign scientific societies Dr. Meissner was a member of the American Physical Society, Optical Society of America and Sigma Xi. He became a member of the Indiana Academy of Science in 1945 and was made a Fellow in 1953. He served as joint chairman with Dr. Ed F. Degering, in 1946, of the Chemistry-Physics Section. He was listed in Who's Who in America and American Men of Science. Following his death he was honored at a special colloquium at the Johann Wolfgang Goethe University at Frankfurt on July 15, 1959, at which Professor R. Moufang spoke about Dr. Meissner's life and work.

Dr. Meissner supervised the work of a number of candidates for the doctorate in physics at Purdue to whom he was able to convey his enthusiasm for scientific research. Despite his apparent feeling of urgency in his own work he was nevertheless patient and considerate in counseling his students in their research efforts.

He was a scholar who not only knew his science and its literature but he was proficient in history, literature and the languages. He spoke and read German, French, Italian and English and he read Latin, Greek and Hebrew. He was a deeply religious man and an ardent student of the Bible who could quote long passages from the scriptures. He held deep convictions on human rights and the freedom of the individual and he had the courage to speak and act in accord with his convictions. A gentle and kindly man with a deep concern for the wronged individual or the underprivileged group he lived and worked for the betterment of humanity. The nation and state as well as Purdue have lost a truly great scientist and citizen.

THOMAS BENJAMIN NOBLE

Indianapolis, Indiana — Laguna Beach, California
January 21, 1895 — December 9, 1958

"Dr. Tom Noble was a rebel. He was an individualist. He was a

genius. He was warmhearted and kind, a cool thinker, a great doctor. But more than that he was a greathearted human being."

Thomas Benjamin Noble represented the fourth generation of a family of Indiana physicians and he bore the same name as his father and grandfather. He was born in Indianapolis on January 21, 1895. Following his graduation from Shortridge High School in 1912 he attended Wabash College for one year and then transferred to the University of Wisconsin and later to the University of Pennsylvania. In completing the requirements for a medical course he received the B.S. degree in 1916 from Washington University and the M.D. degree in 1917.

On May 11, 1917, he volunteered for army service and enlisted as a private, 2nd class. He was assigned to a British General Hospital and saw service in the Passchendale campaign, June to November, 1917, where the first mustard gas attack of World War I occurred and he helped in the research that discovered protective and preventive measures against the gas. While in the service he saw the almost 100% mortality due to disseminated peritonitis and the suffering from the adhesions due to peritonitis and he determined to do something about it. Following his discharge in 1919 as a 1st lieutenant he proceeded to devise an operation which he named plication and used it for the first time on a human patient in 1920 at St. Vincent's Hospital in Indianapolis. The operation was successful and the plication technique came into almost universal use. Dr. Noble succeeded in returning to normal health 96% of his patients suffering from adhesions due to peritonitis. The operation was named the "Noble Plication" by the University of Arkansas, and Dr. Thomeret of Paris, France, named the condition in which intestinal adhesions caused obstruction "Noble's Disease." The Noble Plication was the first of 45 original techniques contributed to medicine or surgery by Dr. Noble. Among them were methods for performing certain abdominal operations by means of incisions that do not cut across trunk muscles, methods of safely uniting the intestine in the presence of peritonitis or obstruction, treatment of generalized peritonitis following war wounds of the small intestine that reduced the mortality from 100% to 4%, methods of restoring ligamental structure in the pelvis following hysterectomy, gall bladder operations and other similar operations, and numerous other improvements in surgical methods. Dr. Noble was a master surgeon.

He wrote many papers discussing his methods and the results of their use which were published in the leading national and international medical journals and he wrote one book "Peritonitis and Its Aftermath." In 1957 he began publication of a Medical Journal of Correspondence which he called "Prologomena Medica" with the motto "Truth lies at the end of the road called 'Controversy,'" and in which controversial and new things in medicine were discussed. It was published monthly in his basement and sent to over 500 physicians and surgeons all over the world and elicited a tremendous response, involving contributed articles and hundreds of letters. An assistant translated the foreign correspondence. He was an excellent photographer and he made photographic records of intricate operations and arranged for their use at schools and conferences of surgeons here and abroad. He originated the Sound Division of the International College of Surgeons in 1945.

Dr. Noble joined the Indiana Academy of Science in 1935 because of his intense interest in archaeology and anthropology. He became interested in Indians in 1915 and first visited the Hopi Indian tribe in 1916. From then on he became the firm and devoted friend of Hopi and Navaho tribes who learned to trust and honor him. Over the years he actively fought for their rights. At the request of the Navaho Council he wrote the Navaho Message to Congress that brought relief from many wrongs suffered by those Indians. Through his efforts and the help of two prominent Arizona friends the land rights of the Hopis were restored to them. In 1952 the governor of Arizona appointed him health consultant for all the Indians of the state. He and Mrs. Noble spent much time in the Southwest recording on film and tape the folklore, songs, religious festivals and dances of the Navahos and Hopis. He reported his results at anthropological meetings. Over the years he presented seven papers before the Academy's Anthropology Section but he did not publish any of his results in the Proceedings of the Academy. In gratitude for his service to them the Indians presented to him numerous tokens and he was often a guest at their religious and other tribal ceremonies. He became interested in the Hopi Indians in his study of cliff dwelling peoples.

Dr. Noble was a Fellow of the International College of Surgeons and the American Board of Surgeons, and the Indiana Academy of Science made him a Fellow in 1956. He was a member of the American and Indiana Medical Associations, Indianapolis Medical Society, American Anthropological Association, New Mexico Historical Society, American Legion, Phi Delta Theta, and the Service, Torch, Literary, Camera and Contemporary Clubs of Indianapolis. He had served on the boards of directors of Flanner House, in Indianapolis, Marion County Red Cross, and Torch International, and he was a Regent International of the College of Surgeons.

Early in December, 1958, he and Mrs. Noble had gone to Laguna Beach, California, on a vacation, but a week after their arrival he was stricken with a heart attack that ended his life on December 9.

Thomas B. Noble was an aggressive leader who had the courage of his convictions. He was a humanitarian who not only healed bodies but also fought for human rights wherever he observed wrongs. This memorial began with a paragraph quoted from an editorial in the Indianapolis Star about him after his death. Following is the closing paragraph of that editorial: "There are many songs of praise we who knew Tom Noble could sing of him. But Tom was the kind of man who never sought praise for himself and would no doubt be embarrassed by it. So we will say only this: If ever a man lived up to the proud name he bore it was Tom Noble—a truly noble man."

WILLIAM EMIL RIECKEN

Mt. Vernon, Indiana — Jackson, Mississippi
January 23, 1892 — January 21, 1958

The trend in the American teaching profession is toward high specialization, be it for teaching in the kindergarten, high school or a special branch of botany, mathematics, etc., in the college or university. The time is probably not far off when special training will be required for eligibility

to become a dean or college president. Then it will be very unusual to find a teacher who has taught in the grades, high school and college and has finally become a dean. Such a teacher was William Emil Riecken who taught all the grades in the rural schools of Posey County, Indiana, from 1911 to 1914, several grades in the Mt. Vernon, Indiana, schools during the next three years, became a teacher in the Mount Vernon Junior High School for three years and was its principal the fourth year. After serving four years, 1924 to 1928, at Indiana University in the Botany Department, the last three years as an instructor, he was appointed Assistant Professor of Botany at Ohio Wesleyan University in 1928, then Head of the Biology Department at Millsaps College in 1934 and finally Dean of the College in 1939.

In the first decade of this century the legal school year in Indiana was six months long and, while most schools were held open longer than this minimum, the educational situation was such that the enrollment in the Spring Quarter at the Indiana State Normal School at Terre Haute was three to four times as great as in the Fall and Winter Quarters. This was due to the further fact that the State began requiring first twelve weeks or one quarter of designated teacher training and this was gradually extended to two quarters, three quarters, and so on as the years went by. Previously most teachers began teaching as soon as they had finished high school and were able to pass the State Teachers' Examinations held at stated times. Thus William E. Riecken began teaching when he was nineteen years of age. He first attended Oakland City College in 1911 and then went to the Normal School at Terre Haute for a term or two in each of the years 1912, 1914 and 1916, to meet the increasing teacher's requirements. His professional progress was interrupted during the years 1917 to 1919 when he served in the Field Artillery in World War I. Following the war he finally completed the requirements for the B.A. degree at Indiana University in 1923. The next year he was principal of the Mt. Vernon junior high school. He accepted an assistantship in the Botany Department at Indiana University in 1924 and received the A.M. degree in 1925. He then became an instructor during the next three years and completed the requirements for the Ph.D. in 1928. It was not uncommon in those days for one to work one's way through college and graduate school and the result was generally a mature, thoroughly trained teacher with both experience and knowledge of subject matter such as was possessed by William E. Riecken.

He was born in Mt. Vernon, Indiana, on January 23, 1892, and practically spent his whole life in the classroom working with young people. While at Millsaps College he was active in the YMCA and the Boy Scouts, teaching nature study at their summer camps and otherwise helping these organizations. However, he taught botany in the summer at Agriculture and Mechanics College of Texas in 1925, Indiana State Normal School, now Indiana State Teachers College, in 1927 and 1931, and Evansville College in 1932. In 1954 ill health forced him to take a leave of absence and he was never able to resume his regular work. He was able, however, to pursue his hobbies of plant collecting, some carpentry, and painting landscapes in oil. He died in Jackson, Mississippi, on January 21, 1958, just two days before his sixty-sixth birthday.

While at Indiana University he joined the Indiana Academy of Science in 1923 and as long as he was in the State he attended the Academy meetings, especially the Spring Meetings. In 1926 he joined the American Association for the Advancement of Science and after he went to Ohio Wesleyan he was active in the Ohio Academy of Science, and he was made a Fellow in the A.A.A.S. in 1933. After going to Mississippi he became a member of the Mississippi Academy of Science and was its president in 1945-46. He was also a member of Phi Beta Kappa, Sigma Xi, Omicron Delta Kappa leadership fraternity, Phi Delta Kappa education fraternity and Alpha Epsilon Delta premedical fraternity. He was listed in Who's Who in America, Leaders in Education and American Men of Science.

Dr. Riecken was active in church work and taught a men's Bible class in Jackson for fourteen years. He was listed in Who's Who in Methodism. He was a member of the Civitan service club. As an excellent teacher, able administrator, fine citizen and Christian gentleman, he lived a most useful and effective life.

ARTHUR ROSENTHAL

Fuerth, Bavaria — West Lafayette, Indiana
February 24, 1887 — September 15, 1959

During the past twenty years Purdue University has made tremendous strides in developing its mathematics offerings and has taken its place in mathematics among the leading universities of our country. Part of this is due to the change in attitude from being merely a service department to the engineering school to that of a field of study of fundamental importance in its own right. A second important factor is its success in having outstanding physicists who also were thoroughly familiar with mathematics as well as mathematicians with national and international reputations. Such a mathematician was Arthur Rosenthal, a native of Germany and a victim of Nazi intolerance, who came to America from the Netherlands in 1940 and became a citizen of the United States in 1945.

Arthur Rosenthal was born in Fuerth, Bavaria, Germany, on February 24, 1887. His keen intellect carried him through the German schools to the doctorate, a Ph.D. in mathematics, at the University of Munich in 1909 at the age of twenty-two. During the following two years he served as an Assistant in the Technische Hochschule in Munich and he spent the year 1911-12 in post-doctoral study in the University of Goettingen. Following his term of duty in the German Army he became a Privatdozent in the University of Munich, was promoted to an assistant professorship in 1920 and two years later was called to the University of Heidelberg as an associate professor. He was promoted to a professorship in 1930 and made Director of the Mathematical Institute. In 1932 he was elected to serve a one-year term as Dean of Science. Nazi racial prejudice forced his retirement in 1935 and he became an emeritus professor at the age of forty-eight, at the height of his power as a scientist. Then followed several years of anxiety and the search for a new home. He escaped to America but his personal library, which was ready for shipment to America, was destroyed in the ruthless bombing of the city of Rotterdam by the Germans. Following his arrival in America he became a Lecturer and Research Fellow at the University of Michigan for the year 1940-41, and, in

1942, he was appointed a Lecturer in mathematics at the University of New Mexico. He was made an assistant professor in 1943 and an associate professor in 1946. The following year he was invited to Purdue as a professor of mathematics and he spent ten happy years there until his retirement as an emeritus professor in 1957. During this period he served as Acting Head of the Department of Mathematics for the year 1955-56. He passed away in his sleep on September 15, 1959.

Dr. Rosenthal was a mathematician with an international reputation. He was author or joint author of nearly forty articles or monographs in the fields of "classical geometry, differential geometry, ergodic theory, set and measure theory, functions of real and complex variables, number theory, didactics and history of mathematics," and extensive articles in the Encyklopaedie der Mathematischen Wissenschaften. He collaborated with L. Zoretti, P. Montel and M. Frechet in the work Untersuchungen uber Functionen reeler Veranderlichen, in 1924, and with M. Hahn in 1948 on a monograph on Set Functions. He also wrote many reviews for both American and foreign mathematical journals and he helped to edit an important posthumous work on measure and integration by his friend, the internationally known C. Caratheodory. He had studied under the great German mathematicians Lindemann, Pringsheim, Sommerfeld and von Weber, and throughout his life he carried on correspondence with other leading mathematicians.

Besides his membership in the Heidelberger Akademie der Wissenschaften, he was a Fellow of the American Association for the Advancement of Science and a member of the American Mathematical Society, Mathematical Association of America, American Association of University Professors, Sigma Xi, Phi Kappa Phi, Kappa Mu Epsilon and Sigma Pi Sigma. He was listed in Who's Who in America and American Men of Science. He joined the Indiana Academy of Science in 1947 and was active in its work, serving as Chairman of the Mathematics Section in 1953, and presenting several papers, abstracts of which appear in the Proceedings of the Academy.

Dr. Rosenthal was a member of Temple Israel in Lafayette and he was a liberal contributor to the philanthropic and education work of the Federation of Jewish Charities of Greater Lafayette.

He was a most charming man and an outstanding lecturer and teacher who had supervised the work of a number of candidates for the doctorate both abroad and at Purdue. At meetings of the Academy and the national and state meetings of the mathematical societies he was recognized as a fine mathematician and a gracious and friendly colleague. The Academy, Purdue and the State of Indiana have lost a splendid educator and citizen.

WILLIAM HENRY SHIDELER

West Middletown, Ohio — Oxford, Ohio
July 14, 1886 — December 18, 1958

One or more members of the Faculty of nearly all colleges and universities have become so associated with the institution over a long period of time that the results of their work have become outstanding and they are known to a wide circle of colleagues, alumni and friends of the institution as a "grand old man or woman of the college." William Henry Shideler

was one of the "grand old men" of Miami University, Ohio, whose whole undergraduate and professional life before retirement had been spent at that university.

Born in West Middletown, Ohio, on July 14, 1886, he entered Miami University in 1903 and graduated in 1907 with the A.B. degree. He spent the next three years at Cornell University as a graduate assistant working on the Ph.D. degree in paleontology which he received in 1910. He returned to Miami as an instructor in zoology and geology, was promoted to assistant professor in 1911, associate professor in 1919, and to Professor of Geology in 1920 with the establishment of a separate geology department. He retired in 1957 as professor emeritus. The year following his retirement he spent in setting up a geology department at Hiram College on a John Hay Whitney grant for retired professors. After completing this work he returned to Oxford where he died a few months later on December 18, 1958, following a cerebral hemorrhage five hours earlier.

While an undergraduate he was one of the four students who founded the Phi Kappa Tau social fraternity on March 17, 1906, which became the fourth national social fraternity to be founded at Miami University. Since its foundation this fraternity has had its Central Office in Oxford, and Dr. Shideler had at one time or other held each of its national offices and he had been its comptroller since 1929. The day before his death he had been to the Central Office to sign vouchers.

Dr. Shideler was widely known in intercollegiate athletics. As an undergraduate he had been a varsity distance runner, and as faculty member he had served as a timer or judge at Miami track meets for nearly a half century. From 1918 to 1956 he was a member of the Miami Athletic Advisory Board and served as its chairman most of those years. He was the faculty representative of Miami to the old Buckeye Conference and to its present successor, the Mid-American Conference, of which he was chairman in 1951-52. He attended numerous meetings of the National Collegiate Athletic Association as the Miami representative.

Dr. Shideler was a practical geologist as well as a fine teacher and researcher. He had served as a field geologist of the Ohio and Kentucky Geology Surveys for a total of nine summers. His principal interests were in Ordovician paleontology and stratigraphy and his fellow geologists had named a number of fossil discoveries for him.

He joined the American Association for the Advancement of Science in 1912 and was made a Fellow in 1921. He was also a Fellow of the Geological Society of America, Paleontological Society and the Ohio Academy of Science. He was vice-president of the Ohio Academy in 1925-26 and its president in 1951-52. He was president of the Association of Geology Teachers in 1954-55 and was a member of Eugenics Society, American Association of University Professors, Phi Beta Kappa, Sigma Xi and Omicron Delta Kappa. He was vice-president of Sigma Gamma Tau geology, mining and metallurgy fraternity in 1954-55. He joined the Indiana Academy of Science in 1929 but he had not been active in its work. He was also a 32° Mason and a Shriner.

Dr. Shideler was listed in Who's Who in America and American Men of Science and he was recipient of the Neil A. Miner Award in 1954.

At a dinner honoring him at the time of his retirement in 1957 a

number of his colleagues and former students set up a scholarship fund in his name and he responded by offering to match their contributions up to the amount of $3,000.

Certainly William H. Shideler will always be listed at Miami University as one of its "grand old men."

RALPH W. SHOWALTER

Fremont, Nebraska — Miami, Florida
September 1, 1885 — March 24, 1959

It is the policy of great corporations like General Motors, International Business Machines and others to keep alert for the aptitudes of their young employees. Those who show unusual research, administrative, sales or other abilities are carefully trained and promoted as their talents develop and mature. This is particularly true of the great pharmaceutical firm of Eli Lilly and Company.

Ralph W. Showalter, who joined Eli Lilly and Company in November, 1909, less than six months after he had graduated from Purdue with a B.S. degree in chemistry, started to work as an analytical chemist. Before joining Lilly he had spent three months as an assistant in chemistry at Purdue and two months as a chemist with the Inland Steel Company in South Chicago. For a time at Lilly's he continued his work in chemistry, moving up through the positions of alkaloidal chemist and research chemist. He then was associated with J. K. Lilly, Jr., in the organization of the efficiency department for the company. When the company entered the field of biologicals Mr. Showalter was selected as one of the early superintendents of production and later was appointed director of the biological division.

Following the end of World War I Eli Lilly and Company began a period of expansion into export fields and, in 1923, Mr. Showalter was named manager of the foreign sales department. This entailed world-wide travel and he went around the world several times representing the company and appointing distributors in South America, Mexico, Europe, Africa and the Far East. Some twenty years before his death in Miami, Florida, on March 24, 1959, he was stricken with diabetes which led to his retirement from active duty in 1944 after thirty-five years of service.

Mr. Showalter was born in Fremont, Nebraska, on September 1, 1885. After graduating from West Lafayette High School he entered Purdue in 1905 and graduated in 1909.

He was a member of Tabernacle Presbyterian Church in Indianapolis. He also held membership in the Surf Club, University Club, Woodstock Club and Indianapolis Athletic Club. He joined the Indiana Academy of Science in 1915 while he was working in chemistry and he maintained a continuous membership for forty-four years despite the fact that his major interests were in other fields.

Mr. Showalter's great contribution in the development of the export of pharmaceutical products to foreign lands not only served his company well but also enabled many peoples in foreign lands to lead happier and more healthful lives.

RALPH BUSHNELL STONE

Templeton, Massachusetts — West Lafayette, Indiana
June 4, 1882 — February 27, 1959

During the school year 1906-07 two students doing advanced study in mathematics at the University of Munich, Germany, met. One was Arthur Rosenthal, a German, and the other was Ralph Bushnell Stone, an American, who had spent the preceding year in advanced study of mathematics at the University of Turin, Italy. Forty years later, after two World Wars, they were to meet again as colleagues in the Mathematics Department at Purdue University, and fifty-two years later, as emeritus professors at Purdue, they both died in West Lafayette, Indiana, within a few months of each other.

Ralph Bushnell Stone was born on June 4, 1882, in Templeton, Massachusetts. He received the A.B. degree from Bowdoin College in 1902 and then entered Harvard University where two years later he got the A.M. degree. He continued his study at Harvard for a third year and then went to Europe for two years of study, one year each at the universities of Turin and Munich. On his return to America in 1907 he taught mathematics and physics as an instructor at Bowdoin College for four years and then returned to Harvard for another year of study. In 1912 he accepted an instructorship in mathematics at Purdue. Two years later he was promoted to assistant professor and appointed assistant to the Registrar. He was made Registrar in 1918 and did not retire from this office until 1947. He became an associate professor in 1922. After retiring as Registrar he continued to teach in the Mathematics Department until his retirement in 1952 as Emeritus Professor of Mathematics.

As Registrar he served as ex-officio Secretary of the Faculty and he continued to serve in this capacity after relinquishing his duties as Registrar until his retirement. He was also secretary of the Executive Committee of the Faculty for many years. In 1924 a special Faculty committee was set up to develop graduate study at Purdue which led to the organization in 1929 of the Graduate School under the supervision of a Graduate Council. Professor Stone served as secretary of the special committee and of the Graduate Council for many years.

Because of his duties as Registrar Professor Stone taught only part time. His excellent broad training in mathematics made him an effective teacher. As an administrator he was most capable, honest and fair.

While a student at Bowdoin he was elected to Phi Beta Kappa in 1901. He had been a member of both the American Mathematical Society and the Mathematical Association of America for more than forty years. He was an honorary life member of the American Association of Collegiate Registrars and Admissions Officers and a member of the American Association of University Professors. He joined the Indiana Academy of Science in 1914 and attended its general meetings when his duties would permit. He served as chairman of the Mathematics Section in 1936.

Professor Stone was a scholar with a keen interest in and appreciation of literature, music, art and world affairs. After his retirement he enjoyed working in his garden and growing beautiful roses. He derived great pleasure listening to fine music on his hi-fi set.

Although he had been seriously ill several different times after his

retirement and although not well he had been fairly comfortable his last two years. He died suddenly and unexpectedly of a coronary occlusion in his home on February 27, 1959.

AGNES ERMINA WELLS

Saginaw, Michigan — Saginaw, Michigan
January 4, 1876 — July 6, 1959

Not many women have become outstanding in science but the Indiana Academy of Science has had several women members who became widely known either as scientists or for distinguished service in other fields. One of the 69 Founders of the Academy was Lillien Jane Martin who long before her death in 1943 at the age of 91 had been Professor of Psychology at Stanford University under David Starr Jordan and was recognized at that time as one of the leading psychologists in the United States. With the death of Agnes Ermina Wells in Saginaw, Michigan, on July 6, 1959, at the age of 83, the Academy lost another outstanding woman member who was trained in mathematics and astronomy but became nationally known as a Dean of Women at Indiana University. She joined the Academy in 1924, five years after coming to Indiana University.

Dean Wells was born in Saginaw, Michigan, on January 4, 1876. After completing her public school education she attended Bryn Mawr College for one year and then enrolled at the University of Michigan and received the A.B. degree in 1903. She was Principal of the Crystal Falls, Michigan, high school for the year 1904-05 and the next year she went to Duluth, Minnesota, as a teacher of mathematics in the high school and was Head of the Department of Mathematics from 1907 to 1914. She then began work on the M.A. degree at Carleton College and received it in 1916 after serving as an instructor in mathematics in the College for the year 1915-16. In 1917 she made a decision that changed the whole course of her life. She accepted the position of Social Director of the Helen Newberry Residence, a dormitory, at the University of Michigan and was acting Dean of Women in the summer of 1917 and the year 1918. At the invitation of President William Lowe Bryan she came to Indiana University in 1919 as Dean of Women and served in this capacity until retirement at her own request in 1938. She remained at the University until 1944 as Professor of Mathematics and Astronomy and then retired as Dean of Women Emerita. While at Indiana University she completed requirements at the University of Michigan for the Ph.D. degree in astronomy which she received in 1924.

At the University of Michigan in 1918 Dean Wells helped to found Mortar Board when representatives of women's honoraries at Swarthmore College, Cornell University, Ohio State University and the University of Michigan met at Syracuse, New York, to form a national honorary for senior women. At Indiana University she helped to found the chapter of Mortar Board there in 1921 and served as an adviser until her retirement.

Dean Wells is generally credited with establishing the women's dormitory system at Indiana University. At her retirement in 1944 President Herman B Wells stated: "For 20 years Miss Wells has been more than Dean of Women. Not only has she discharged the routine duties of her office with extraordinary skill and great success, but she has worked

diligently to further the program of education here and elsewhere. The beginning of our dormitory system is generally attributed to her far-sighted and energetic leadership. Throughout all her administration she has maintained standards of scholarship and character of very high order."

She had an outstanding record of leadership in women's club work. While Dean of Women she served as president of both the Indiana and National Associations of Deans of Women and she was state president of the Business and Professional Women's Clubs. She was active in the D. A. R. and was Regent of the Bloomington Chapter in 1945-46. In 1943 she joined the National Woman's Party, with headquarters in Washington, D. C., and following her retirement she served for a number of years after 1945 on its National Council and as its president from 1949 to 1951.

She was a member of the American Astronomical Society, American Association of University Women, American Association of University Professors, National Education Association, Indiana State Teachers Association, Phi Beta Kappa, Sigma Xi, Iota Sigma Pi chemical sorority, Pi Lambda Theta education sorority, and Gamma Phi Beta social sorority. Dean Wells was also a devoted Episcopalian. For a number of years she was listed in Who's Who in America and American Men of Science.

Agnes E. Wells was a most talented woman with considerable scientific ability. However, she devoted most of her professional life to the guidance of college women students and the improvement of women's status in our complex American civilization. A woman of great integrity and deep sincerity, she left a lasting influence for good in the lives of the many thousands of humans with whom she worked.

PRESIDENTIAL ADDRESS

A Case History of Evolution

Ralph E. Cleland, Indiana University

This is the 75th annual meeting of the Indiana Academy of Science. The first meeting was held in Indianapolis in 1885 and it is fitting that this one should also be held here. It is indeed gracious of Butler University to place its facilities at the disposal of the Academy for this anniversary occasion and we are much in the debt of President Ross and those at the university who have worked so hard to make this meeting an outstanding one, especially to Dr. Wm. Bessey, chairman of the Program Committee, and his able associates.

The first president of the Academy was David Starr Jordan and the second was John M. Coulter. There were giants in those days. Both men were noted students of evolution, the one in animals, the other in plants. It would not be inappropriate, therefore, on this occasion to center our discussion around the topic of evolution, especially as it happens that for scientists, and especially for life scientists, 1959 is a very special anniversary year, the centenary of the publication of Chas. Darwin's Origin of Species. The appearance of this book is perhaps the most significant single event that has transpired in the history of modern science, for it revolutionized scientific thinking, not only in biology, but in the other sciences as well, and gave to post-Darwinian science a character, a point of departure, radically different from that of the pre-Darwinian period. Darwin's great contribution was that he brought forward convincing evidence in support of what had been prior to this time an unproved hypothesis in the minds of a handful of men. Darwin's contribution not only convinced biologists in general of the fact of organic evolution, it started scientists in other fields thinking in evolutionary terms. Intrigued with the thought of progressive evolution, scientists began to apply evolutionary thinking to the question of origins in all fields—the origin of the elements, the earth, the planets, the stars and galaxies; and the universe of which we are a part began to take on added intelligibility when interpreted as the result of a long and continuous process, involving the operation of physical and chemical laws in a universe of matter. Sciences before and after Darwin were very different disciplines, differently oriented, differently pursued.

It is therefore rather surprising to realize that, although Darwin's work has had such a profound influence in persuading scientists of the reality of evolution, very few cases have actually been found in which the forces that have operated to bring about specific evolutionary changes have been identified and the changes analyzed in detail. The organisms that have been studied with sufficient thoroughness so that we know not only what steps have taken place in the course of evolution, but also what the nature and relative importance of the factors bringing about these changes have been are few indeed. There are a good many cases where evolutionary changes can be traced, as in the horse or elephant, but the causal factors that brought these transformations about are either unknown or a matter of speculation.

I wish this evening to give in brief outline an account of one organism

in which some of the causal factors are becoming understood. This is probably a fitting subject for discussion in connection with the anniversary of both the Indiana Academy of Science and the Origin of Species.

The organism in question is the evening primrose, *Oenothera*. This is a large genus, native only to the Western Hemisphere, though now widespread in other parts of the world. It consists of 15 subgenera, only one of which, the largest, and the one that has been most studied, will be discussed here *(Euoenothera)*.

Curiously enough, it was in connection with evolutionary studies that *Oenothera* first came into scientific prominence. de Vries used it as the principal basis upon which he founded his celebrated and influential Mutation Theory of Evolution. It turned out, however, that the phenomena which he observed in *Oenothera* and which led him to this theory were not what he thought they were, and did not support his theory. In consequence, *Oenothera* lost for a time its central evolutionary interest. It continued, however, to be of cardinal importance to biologists because of its peculiar hereditary behavior, analyzed so successfully by Renner and his students. It later became a center of cytological and cytogenetic interest because of the peculiar behavior of its chromosomes at the time that reproductive cells were formed, a behavior that accounted satisfactorily for its unusual hereditary behavior. In recent years, however, it has again become the subject of intense evolutionary study, for it turns out that one can trace evolutionary developments and determine relationships between the various populations by utilizing clues afforded by its cytogenetic behavior.

In order to understand the nature of the evolutionary factors operating in this genus, it will be necessary briefly to explain the peculiarities in cytological and genetical behavior which *Oenothera* displays. Oenotheras have 14 chromosomes. Instead, however, of these chromosomes arranging themselves in pairs at the formation of reproductive cells, as they do in other plants and animals, they are arranged end to end to form a closed circle (fig. 1A). At the time of separation of these chromosomes into the

Fig. 1. Chromosomes of *Oenothera*, arranged in a closed circle of 14. A, sometime prior to separation. B, just before separation of adjacent chromosomes to different cells.

daughter cells, the chain becomes aligned across the cell (fig. 1B), and adjacent chromosomes are separated to opposite ends of the cell, and hence into different reproductive cells. It turns out that chromosomes of paternal and maternal origin alternate in the chain (fig. 2); consequently, separation of adjacent chromosomes means that all seven chromosomes

Fig. 2. Diagram showing that chromosomes of paternal and maternal origin are separated into different reproductive cells.

of paternal origin go to one daughter cell, all seven maternally derived chromosomes go to the other. As a result, only two kinds of reproductive cells are produced, genetically speaking, and these are genetically identical with the germ cells that united to form the plant.

One would expect that, since only two kinds of egg and two kinds of sperm are formed, self pollination would result in three kinds of offspring, one quarter receiving the *a* set of chromosomes from both sperm and egg, one quarter receiving *b* sets from both, and one half receiving the *a* set from one and the *b* set from the other. This does not happen. Only individuals receiving one *a* set and one *b* set are formed (fig. 3). This is

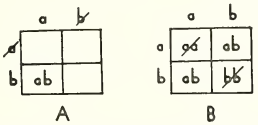


Fig. 3. Diagrams to show action of lethals. A. Lethals that kill gametes. The paternal set of chromosomes (a) has a lethal that kills all eggs receiving this set. The maternal set (b) has a lethal that inhibits sperms that receive this set. B. Lethals that kill organisms which receive this lethal through both sperm and egg.

because each set of chromosomes contains what is known as a lethal which makes it impossible for an individual to receive the same set through both sperm and egg. Consequently, a plant when selfed produces only progeny that are identical with itself genetically. To cap the climax, it turns out that practically all oenotheras with circles of 14 are by nature self-pollinating. Consequently they form true-breeding lines or races, more or less isolated from each other reproductively because they ordinarily do not experience cross pollination. The population as a whole consists of a multitude of such races, in each of which all individuals in all generations are as a rule genetically identical (fig. 4).

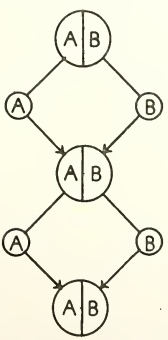


Fig. 4. Diagram to show that an *Oenothera* plant produces only progeny like itself, and consequently breeds true.

One curious result of this situation is that single sets of genes (the *a* set and the *b* set, for instance) are carried on intact from generation to generation. The union of all chromosomes into a single circle, the separation of adjacent chromosomes into different germ cells, and the presence of lethals in each set of genes, coupled with self pollination, mean that a given set of chromosomes with its genes is an entity of indefinite duration. Renner called such continuing sets of genes "complexes" and they are now known as "Renner complexes." A race with a circle of 14 and balanced lethals (i.e., a lethal in each complex) is called by Renner a "complex-heterozygote" because it is heterozygous or hybrid in that it has 2 different complexes and is prevented by the lethals from having a complex in double dose. Each race has its own complexes and different races have, as a rule, different complexes for which they are heterozygous.

Why do the chromosomes arrange themselves end to end in closed circles instead of pairs? This has been found to be due to a process known as reciprocal translocation. Suppose we postulate a race with only paired chromosomes. There will be two chromosomes of each kind and when germ cells are in the process of formation, each chromosome will seek out the one that corresponds with it and will pair with it by a process known as synapsis, which is a mysterious attractive force that develops between corresponding chromosomes during germ cell formation. Let us give numbers to the ends of a couple of pairs, 1 and 2 for one pair, 3 and 4 for

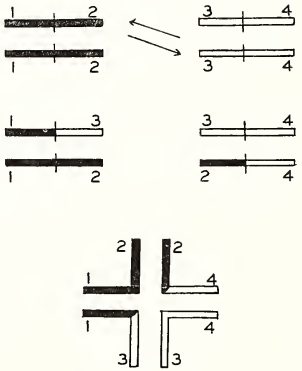


Fig. 5. Diagrams to show how an exchange between non corresponding chromosomes will result in a circle of 4 chromosomes.

another (fig. 5). Now suppose that an exchange of segments occurs between two non-corresponding chromosomes. The unchanged chromosomes will have ends 1 and 2, 3 and 4 but the changed chromosomes will have ends 1 and 3, 2 and 4. One germ cell will get 1.3 and 2.4 and the other 1.2 and 3.4. When a plant which has received 1.2, 3.4 from one parent and 1.3, 2.4 from another forms germ cells, synapsis between corresponding parts of chromosomes will produce a circle of 4 chromosomes instead of two pairs. By successive interchanges, plants with larger and larger circles can be formed.

In other words, sequences of reciprocal translocations result in a shuffling of the end segments of chromosomes, and the various complexes in the various races have come to have various associations of end segments by such a shuffling process, each complex, however, having always

the same arrangement. There are 135,135 possible arrangements of 14 ends in pairs to form the 7 chromosomes of a set or complex. No one knows how many arrangements exist in nature, but the tiny sample of races that we have analyzed has yielded over 160 different arrangements, and there are no doubt many hundreds, if not thousands, of arrangements in existence.

If two complexes differ by one interchange they will form a circle of 4 and 5 pairs when combined in a single plant. If they differ by two interchanges, they will give when combined two circles of 4 or a circle of 6. If they differ with respect to all their chromosomes they will in most cases produce a circle of 14. It is amazing that in almost every race from the Rockies eastward the associated complexes differ so greatly from each other that they yield a circle of 14.

Some studies made 30-35 years ago suggested strongly that the more closely complexes are related genetically the more alike will they be in segmental arrangement, and vice-versa, and subsequent studies have tended to confirm this suggestion. This means that the complexes found in most wild races are genetically unrelated to each other. On the other hand, complexes in different races are often closely related.

This summary will give us a glimpse of the unusual chromosome behavior in *Oenothera*, which results in peculiar genetic behavior. It will also help us realize that the *Oenothera* population is peculiarly constructed, being composed of a welter of true-breeding races, each isolated from the others reproductively by its self-pollinating habit, each composed of two unrelated complexes, which complexes, however, are closely related oftentimes to complexes in other races. What have been the factors that have brought to pass this unusual situation?

Without going into detail in regard to the evidence, for which there is no time, I can outline the situation briefly, as it appears to us at present.

In the first place, the evolution of this peculiar situation could not have come about if the ancestral oenotheras had not had a particular type of chromosome structure to start with. The ancestral forms seem to have had chromosomes with the following characteristics: (a) they all had the same size and shape; (b) they all had two equal arms, the part of the chromosome that actively moves toward one end of the cell or the other (the so-called centromere) being in the middle of the chromosome; (c) the chromosomes were all more fragile in the immediate region of the centromere than elsewhere, so that when breaks occurred, these breaks were more likely to occur at the centromere than elsewhere. We shall see shortly why these facts are important.

The second important factor in the evolution of the oenotheras is the occurrence and retention of translocations or exchanges of segments between non-corresponding chromosomes. While such exchanges are known in other organisms, there is no other organism where they have occurred as frequently, or at least have survived as frequently as in *Oenothera*. The reason for the frequency of survival of exchange chromosomes in *Oenothera* is to be found in the fact that exchange chromosomes have not been altered structurally. Because breaks occur at the centers of equal-sized chromosomes, exchanged segments are equal, the centromeres in the resulting circle are equally spaced, the forces are uniformly distributed

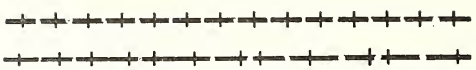


Fig. 6. (Upper line). Chromosomes are all of equal size, have median centromeres which are thus equally spaced in the circle. (Lower line). Chromosomes are unequal in size and length of arm, and centromeres are therefore unequally spaced.

and the chromosomes separate with a high degree of regularity (fig. 6, upper line). In other organisms, chromosomes are often of differing size and shape, and the exchanges of segments may be unequal between chromosomes with unlike structure. As a result, when a circle is formed, the centromeres will be unevenly spaced around the circle. Some of them may be close together, others farther apart (fig. 6, lower line). In consequence, the forces operating at the centromeres to move the chromosomes to opposite ends of the cell are unevenly spaced and a regular separation of adjacent chromosomes does not uniformly occur. Adjacent chromosomes often go into the same germ cell instead of different ones. This means that a daughter cell gets some genes twice and fails to get other genes at all. The germ cells resulting from such irregular separations fail to develop because they lack certain genes, and sterility results. In *Oenothera* this occurs only exceptionally.

In most organisms, reciprocal translocation must be classed as a harmful phenomenon because it leads to irregular distribution of chromosomes to the reproductive cells and hence results in sterility. In such organisms, a translocated chromosome tends to get weeded out because the germ cells getting it are often sterilized. The only cases where translocations between unequal chromosomes have managed to survive are in plants that are able to propagate vegetatively and hence are more or less independent of the sexual process. In *Oenothera*, however, translocations have not proved deleterious, because they do not alter chromosome structure and hence do not bring about the unequal distribution of forces that cause failure of regular separation of paternal and maternal chromosomes.

Translocations, then, are the second factor of evolutionary importance in *Oenothera*. They are important because they have made the large circles possible.

The third factor of evolutionary importance in *Oenothera* is the appearance and retention of lethals. It is the lethals that ensure that the races will breed true and that they will be maintained in a heterozygous condition, i.e., with two different complexes in each plant. Lethals in most organisms are highly deleterious. They kill, either the germ cells in which they come to lie or the embryos which receive the same lethal from both parents. If a lethal is the kind that kills eggs, it will kill half of all the eggs produced since half the eggs will have this particular gene. If it kills sperms, half the sperms will be inactivated. If so-called zygote lethals are present (i.e., lethals that kill embryos which receive them twice), and the plant is selfed, each lethal will kill one quarter of the progeny; and if both complexes have such a lethal, one half of all the progeny will be killed by the lethals. *Oenothera* is no exception to this. The lethals do kill, in *Oenothera* as in other organisms.

In *Oenothera*, however, the lethals have tended to survive in races that have circle 14, and not to be weeded out, because they have compensating advantages. These advantages stem from two facts: (1) lethals,

when present in a large circle, preserve the heterozygosity (the hybridity) of all the chromosomes in that circle, and thus ensure and maintain maximum hybrid vigor. They do so at the cost of 50% sterility of the germ cells or embryos, but those plants that are produced are unusually well equipped for the struggle for existence. Maximum hybrid vigor gives them a high level of survival value. (2) Balanced lethals in a circle of 14 help to make the race true breeding. If it is a vigorous, successful race, all individuals in the race, in all generations, will show this vigor and this success.

Lethals in paired chromosomes do not afford sufficient advantage to compensate for their killing effect. A lethal in a chromosome that forms a pair with its corresponding chromosome will kill 50% of sperms or eggs, or one quarter of the embryos, just as will the lethal found in a circle of 14, but it will not produce true breeding, and it will preserve the heterozygosity of one chromosome only, which is not enough of an advantage to compensate for its bad effect. True breeding and maximum hybrid vigor are found only when all chromosomes are included in a single circle. This is no doubt why almost all races from the Rockies eastward have a circle of 14. Only those with a circle of 14 have survived.

A fourth factor of importance is the development of a self-pollinating habit. Self pollination is ordinarily a harmful practice, for it results in close inbreeding with consequent loss of hybrid vigor and general deterioration. In the case of the evening primrose, however, this cannot occur, for the lethals present in a circle of 14 ensure the maintenance of heterozygosity of all the chromosomes, and by preventing homozygosity prevent the weakening that would ordinarily come about through inbreeding. On the other hand, inbreeding confers a benefit in *Oenothera*, in that it helps to overcome the sterilizing effect of the lethals. The flowers of the evening primrose do not have to depend on the chance visits of insects, bringing sometimes abundant, but sometimes scanty, supplies of pollen. Self pollination ensures that, in every healthy flower, the stigma will be covered with pollen and as a result every viable egg will be fertilized. Since self-pollination occurs many hours before the flower opens, the eggs are being fertilized, or have already been fertilized by the time insects reach the flower with foreign pollen.

We have, therefore, a number of factors which, taken together, make for true-breeding, vigorous, highly prolific plants. Equal-sized and equal-armed chromosomes, more easily broken at the center than elsewhere, make it possible for translocations to survive. Translocations, lethals, and self pollination are all deleterious alone, but taken together each overcomes the bad effects of the others and the combination of the three is highly advantageous to the plant. One may conclude that apparently deleterious changes do not always have a bad effect, are not always to be considered retrogressive in nature.

But how have the large circles come about? Have they gradually developed as the result of successive translocations, small circles gradually becoming larger and larger as interchange has been piled on interchange? The evidence seems to indicate that this is not how the large circles have come about. A fifth factor has proved to be of evolutionary importance in the genus, namely hybridization. Large circles have been produced by

hybridization. In order to understand the role of this factor, it is necessary to explain briefly how the facts to be presented have been obtained.

Assuming as a working hypothesis that complexes whose chromosomes have similar arrangements of ends are closely related, whereas those with dissimilar arrangements are relatively unrelated, we have attempted to analyze the arrangements of ends in as many complexes as possible in terms of a standard complex. We chose as our standard one that seemed to us on various grounds primitive and possibly possessed of the original end arrangement. By a process of reasoning too complicated to go into here, we have determined the arrangement of ends in more than 360

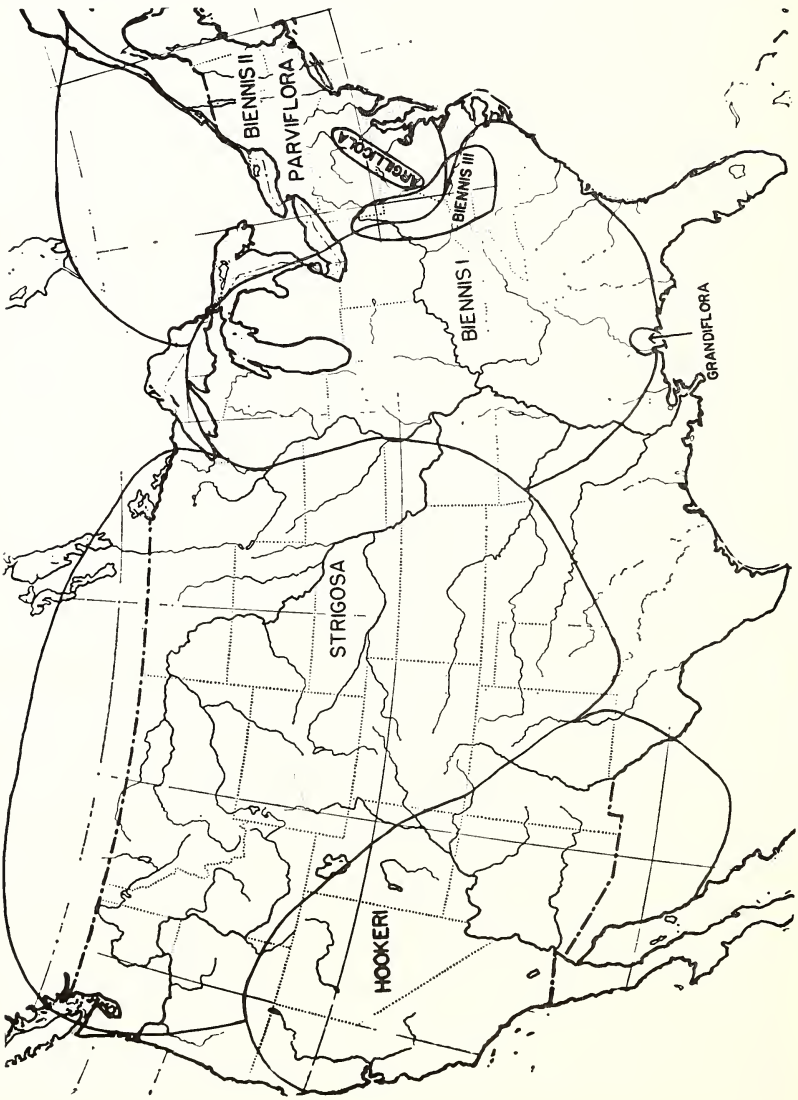


Fig. 7. Distribution of the major groupings of Euoenothera.

complexes in terms of the standard. Thus the standard complex *(hookeri)* was given the arrangement 1.2 3.4 5.6 7.8 9.10 11.12 13.14, where the ends of the chromosomes are numbered and arranged in sequence. One chromosome has ends 1 and 2, another 3 and 4, etc. Some complexes proved to be very similar to *hookeri*, e.g., the egg complex of *chicaginensis* has 1.2, 3.4 5.6 7.10 9.8 11.12 13.14. Other complexes differ completely from the standard, e.g., one of the complexes of the *grandiflora* of de Vries *(truncans)* has 1.13 3.7 5.2 4.6 9.14 11.10 8.12. Over 160 different arrangements have been found among the complexes analyzed. When these complexes are compared with one another from the standpoint of similarity or dissimilarity of end arrangement, geographical position and the external appearance of the plants of which they are a part, we find that these complexes and the races to which they belong fall into certain rather distinct groupings, each group of races having its own special geographical range, its own distinctive appearance and certain characteristic types of segmental arrangement in common. Ten such groupings have been found. They have been given tentative designations as follows (fig. 7): *biennis*-like *parviflora*, *strigosa*-like *parviflora*, *argillicola*, *biennis I*, *biennis II*, *biennis III*, *grandiflora*, *strigosa*, *hookeri*, *elata*. When we analyze the various segmental arrangements and try to see what interchanges have occurred to form them, we begin to see how these groupings have come about and I will now briefly tell the story of the way in which they have evolved.

The first *Oenothera* population that spread over the North American continent had certain rather distinctive structural features that showed it to be closely related to the subgenus *Raimannia*. We may call it the *proto parviflora* population, or population 1. Its leaves were narrow, relatively hairless, its stems tended to bend down behind the tips and then up at the tips, its sepal tips were subterminal—set off to one side of the tip of the bud. This population was apparently open pollinated with paired chromosomes for the most part. However, interchanges occurred here and there that introduced into the population a considerable variety of segmental arrangements. Large circles probably did not develop, nor did lethals become established. There is a relic of this population still extant in the shale barrens of the Appalachians. It is known as *argillicola*. It has large flowers, open pollination and small circles or none. Lethals are for the most part absent. It has bent stem tips and subterminal sepal tips.

At a later time, a second population developed which we may call the *proto-biennis* population, probably in what is thought of as the center of migration, namely, Central America. This probably arose during one of the periods when the Pacific Southwest was experiencing a wet climate, and this population was adapted to such conditions. As it spread into the area of the United States it came into the territory occupied by the first population. The second population, like the first, was open pollinated, free of lethals, and had small circles or none. A certain amount of heterogeneity in segmental arrangement probably developed, especially as the population spread eastward, although there seems not to have been too much in the way of segmental interchange in the middle western areas. Individuals of this second population crossed here and there with individuals of the first population, which they could do because both popula-

tions were open pollinated. Because, however, the interchanges which had taken place in the two populations were by chance entirely different, the segmental arrangements of some of the plants that crossed were different enough to give the progeny of these crosses a circle of 14, which is formed when none of the chromosomes contributed by the male parent coincide with any of those contributed by the female in segmental arrangement. In this way, circles of 14 arose suddenly and not by the gradual accumulation of translocations in a single line of descent.

Once circles of 14 appeared, the stage was set for the retention of lethals, as explained earlier. Some of these may have been in existence in population 2 before crossing took place, in the form of a special kind of sterility factor known as an S factor. A pollen grain that has a certain S factor cannot grow a tube down through the style of a plant possessing the same S factor. This makes it impossible for such a plant to reproduce by self pollination, and in a naturally open pollinated race this is an advantage because self pollination would lead to weakening resulting from loss of hybrid vigor. If S factors were present in population 2 when a cross occurred between it and population 1, the progeny would receive the S factor in the complex derived from population 2. This complex would not be capable of transmission through the pollen because of the S factor, and the hybrid would automatically have a pollen lethal. That population 2, the *proto-biennis* population, did possess S factors is suggested by recent work of Steiner.

The so-called egg lethal that developed in these hybrids and which was formed in the complex derived from population 1, may not have been in reality a lethal at all. It may have been merely a case where the complex derived from population 1 was unable to compete with the one from population 2 in the formation of eggs. An ovule or incipient seed in a flowering plant produces 4 cells, each of which is capable theoretically of developing the structure that contains the egg. In *Oenothera*, 2 of these 4 cells will receive one complex, 2 will receive the other. A competition then develops between the cells containing the two complexes. One of them will win out and produce the only egg developed in the ovule. It has been found experimentally that a given complex competes with different degrees of success with different complexes. If in the hybrids produced between populations 1 and 2 the complex from population 1 competed badly with the one from population 2, we would have what would seem to be an egg lethal in the population 1 complex, but in reality it would not be a lethal in the sense that it would actually destroy the egg. And so we see that a balanced lethal situation might have been produced at the very start of certain hybrids between populations 1 and 2. An S factor brought in with the complex from population 2, coupled with inability of the complex from population 1 to compete in egg formation with the complex from population 2, would give to a hybrid with a circle of 14 a so-called balanced lethal situation. With each such hybridization we would then have the beginning of a race typical in cytogenetic behavior of present day races except for the absence of the self pollinating habit. The latter came subsequently, and whenever it appeared, it gave such advantage to the plant in overcoming sterility due to the lethals that it was retained. In the struggle for existence, plants possessing self pollination coupled with a circle of

14 and balanced lethals survived, those without self pollination lost out.

It is not to be thought that only one cross took place between populations 1 and 2, or that the whole of a population crossed with the whole of another. Only here and there did individual plants cross. In some cases the hybrids thus produced had a circle of 14. From these are derived present day races. Other hybrids no doubt had smaller circles and because they could not breed true, and because the maximum of hybrid vigor would not be attained in their case, they lost out in the struggle for existence. The overlapping of populations meant, then, that many crosses occurred throughout the range, some of which died out, others with a circle of 14 survived. From each or many of these, have come the present day races of the group that we call the *biennis*-like parvifloras. They combine *biennis* and *parviflora* characteristics, with the latter having the larger influence on the external features of these races.

A relic of population 2 in its pure form still exists in the region of Mobile, Ala., and goes under the name of *grandiflora*. It is large flowered, open pollinated, is free of lethals and has only paired chromosomes.

This story of overlapping of diverse populations and the creation by hybridization of a new population took place twice again at later periods. There came a time when the moist period in the south-west ended. Arid conditions became established. As a result, evening primroses of populations 1 and 2 died out in most of the western half of the continent, although small islands of plants resembling population 2 have survived in isolated, well watered spots in the west. With aridity, there developed in the center of origin a third population, this time adapted to drier conditions. It resembled the present day *strigosas*, except that it had open pollination, mostly paired chromosomes and no lethals. This population invaded the western plains areas and the northern Rockies, and as it spread, interchanges took place between its chromosomes different from those that had occurred in populations 1 and 2. As population 3 (the *strigosa*-like population) advanced eastward, it invaded the territories of populations 1 and 2 and found plants of these populations that had not crossed with each other, that still had open pollination, small circles or pairs and an absence of lethals. Individuals of population 3 thereupon crossed with individuals of populations 1 and 2 and in particular cases circles of 14 resulted. Perhaps the same sort of story took place with respect to the origin of lethals and self pollination that had taken place in hybrids between populations 1 and 2. As a result, new populations arose with circles of 14, balanced lethals and self pollination. Crosses between populations 1 and 3 gave rise to what we now call the *strigosa*-like parvifloras. Crosses between populations 2 and 3 gave rise to what we call the *biennis* group. Population 1 gave to both the *biennis*-like and the *strigosa*-like *parvifloras* what we call the *parviflora* characters—narrow, hairless leaves, bent stem tips and subterminal sepal tips. Population 2 had what we call the *biennis* characters—broad, thin, crinkly leaves with little hairyness, and brittle stems. These characters tended to dominate in the races established by the crossing of populations 2 and 3, and which are known as *biennis* races. Population 3 had moderately narrow, thick and hairy leaves, and tough, woody stems. We call these the *strigosa* characters. The *biennis* group resulting from the crossing of populations 2 and 3

combined a *strigosa* with a *biennis* complex, the latter tending to dominate.

This story was repeated once again. A fourth population arose later, similar in external characters to population 3, i.e., a *strigosa*-like population, but with a history of interchange different from population 3. Population 4 overlapped population 3 and because plants were still in existence in both populations that were open pollinated, crosses occurred. Plants were formed here and there with circles of 14, and lethals and self pollination followed, as had been true in the earlier hybrid populations. The present day *strigosas* are the result. These have a circle of 14, balanced lethals and self pollination, but both of their complexes, so far as their effect on external appearance is concerned, are *strigosa*-like.

There is one population that has developed as did the earlier populations, with open pollination, absence of lethals, mostly paired chromosomes, though with a certain amount of heterogeneity in segmental arrangement, but which has never had an opportunity to overlap and cross with another population of open pollinated plants having a different history of interchange. This population has developed west of the continental divide and is characteristic of the Pacific south-west. It is the *hookeri* group. This group shows primitive characteristics, not only in having paired chromosomes, no lethals and large, open-pollinated flowers, but also in its segmental arrangements, the commonest arrangement being the one that on other grounds is considered to be the original one. It may be that this is an early population that, because it was on the west side of the divide, failed to come into contact with populations developing on the eastern side, or it may represent a relatively new population. In any event, the *hookeris* help us visualize what each of the 4 populations just mentioned was probably like at the time of its migration and overlapping with other populations.

There is another population which is found in Mexico and Central America to which Munz has given the name *elata*. This is of uncertain position. In appearance it shows similarities to *hookeri* and *strigosa*. So far as it has been studied, it has rather large, open pollinated flowers, paired chromosomes and no lethals. Its segmental arrangements, however, tend to depart from what is considered to be the original arrangement by two or three interchanges. Decision as to its status, its relation to other groups, must be withheld until more is known about it.

Two additional points that have to do with the evolution of the *biennis* group have not been mentioned. It has been found that *biennis* races fall into three rather distinct groups. *Biennis* I is characteristic of the middle west. Its *biennis* complexes have pollen lethals, perhaps S factors originally. Its *strigosa* complexes fail in most cases to compete successfully in egg production. *Biennis* II is characteristic of the northeastern part of the continent. It is scarcely distinguishable from *biennis* I in external appearance, but it is its *strigosa* complexes that have the pollen lethals and its *biennis* complexes that fail to compete in egg formation, just the reverse of the situation in *biennis* I. It may be that *biennis* II races are descended from ancestors in which the S factors which had come to function as pollen lethals became transferred from the *biennis*-like to the *strigosa*-like complex by the process of crossing over.

Segmentally the *biennis* I egg complexes are close to the original; the

biennis complexes of *biennis* II are farther removed from the original and show more variation in segmental arrangement from complex to complex. The *strigosa* complexes of both *biennis* I and *biennis* II are somewhat similar segmentally and rather similar to the complexes which are transmitted through the sperm in *strigosa*. For this reason the sperm complexes in *strigosa* are supposed to be derived from population 3 which overlapped the earlier *biennis* and *parviflora* populations; it was in turn overrun and contaminated by population 4 which is now represented by the egg complexes of the *strigosas*.

Finally, there is, in the areas where *biennis* I and II overlap, a third class of *biennis* races, designated as *biennis* III. These, like all other *biennis* races, have a circle of 14, balanced lethals and self pollination. They do not, however, possess a *strigosa*-like complex: both of their complexes are *biennis* complexes, so that *biennis* III races are pure *biennis*. *Biennis* III has no doubt arisen in comparatively recent times from crosses between *biennis* I and *biennis* II. Their egg complexes are very similar in segmental arrangement to the egg complexes of *biennis* I, and their pollen complexes are very similar or often identical in segmental arrangement with the pollen complexes of *biennis* II. *Biennis* III has come about, therefore, by crosses between *biennis* I as female and *biennis* II as male, a fact attested by its geographical location in the regions where *biennis* I and II overlap. Theoretically one should also get in this region the reciprocal cross between *biennis* II as female and *biennis* I as male. Actually we have found only one such plant and it had a circle of 6 and 4 pairs. The *strigosa* complexes in *biennis* I and II are similar enough segmentally that hybrids bringing them together will have small circles; and because plants with small circles do not breed true and do not have full hybrid vigor, they apparently do not survive readily in nature. Consequently this particular theoretically possible population has not caught on.

But it may be asked how self-pollinating races such as *biennis* I and II can cross. This leads me to the final point in the story, namely, that although the races formed by the crossing of ancestral populations are self pollinating, they are nevertheless capable of crossing with other races if the barrier set up by self pollination is broken down. Actually, the barrier does break down occasionally. While in general two races will not cross, even if growing together, a cross will occasionally occur when for some reason or another a flower fails to develop enough pollen to take care of all its eggs. Then, when the flower opens and insects visit it, the pollen they bring with them may have a chance to function. Hybrids are thus produced in nature, but only rarely. If these hybrids have a circle of 14, they may become the beginning of new races, and successful crosses between *biennis* I and II have in this way been occasionally produced. In many cases, however, outcrosses will produce hybrids with other configurations than a circle of 14, and these are usually unable to survive.

In the North American euoenotheras, then, the story of evolution is becoming clear in its main outlines. Successive populations, each overlapping earlier ones, and being overlapped by later ones, have crossed, forming hybrids which have given rise to races that have survived to the present day. The *Oenothera* population as a whole consists of true-breeding, isolated lines, rarely crossing with each other. Their present

condition is the result of the combination of the following factors: (a) chromosomes that were originally of uniform size and shape, with central centromeres and a tendency to break more easily in the centromere region than elsewhere; (b) translocations which were able to survive and accumulate because they did not disturb the morphology of the chromosomes; (c) hybridization between populations that had suffered different histories of interchange, thus producing hybrids with a circle of 14; (d) retention of lethals when circles of 14 were present because they ensured maximum hybrid vigor and true breeding; (e) self pollination which was unable to reduce hybrid vigor when balanced lethals were present, but which encouraged rich pollination, and with the lethals made the races true-breeding. Most of these characters by themselves would be harmful to the plant, but when brought together, and when originating in the particular sequence that I have outlined, they have made for a high degree of vigor and survival value.

I would only point out one thing more. *Oenothera* has to a certain extent sacrificed racial well being for individual well being. The development I have outlined has made for vigorous individuals well able to compete in the struggle for existence. The penalty that has been paid is that the populations that have developed are composed of innumerable isolated lines. When a mutation occurs it is usually recessive and will show out only when an individual is formed pure or homozygous for this change. This ordinarily cannot take place in *Oenothera*, for pure races and purity of genes are very difficult to achieve in view of the enforced heterozygosity. Only when a rare outcross occurs is there a chance of chromosome pairs being formed and recessive genes being able to show up. But hybrids that have pairs usually are unable to survive. The best, and almost the only chance that a recessive gene will produce an effect will be if it gets into combination, through outcrossing, with a different gene in a new hybrid with a circle of 14. It may possibly be able to exercise some influence in a new combination.

The future evolution of *Oenothera* will probably take the form of a gradual increase in the number of true-breeding isolated lines, through rare crosses producing hybrids with a circle of 14. If conditions should change radically, the relative inability of recessive genes to show out might reduce markedly the plasticity of the genus and its ability to adapt to change. The main hope of the subgenus would be that among the plethora of races then existent there might be some that would be able to survive the changes, and hence preserve the group from extinction. It is not too much to say, however, that the inability of genes to circulate freely in the population and to show up occasionally when recessive would constitute a serious threat to the permanence of the genus should conditions change. Future survival of the race may have been sacrificed for increase of survival value of the individual.

I have briefly outlined a single story of evolution. It is in many respects a unique one and different from what has happened in other groups. It is important, however, to look for cases where one can analyze in detail the story of evolution. In this way we can learn more about the nature of evolutionary change and the factors that determine the survival or disappearance of the changes produced.

ANTHROPOLOGY

Chairman: GEORG K. NEUMANN, Indiana University

M. S. WADIA, Indiana University, was elected chairman for 1960

ABSTRACTS

A Review of Human Geneology. NATHALIE FEDYNSKYJ, St. Mary's College.—This review concerns the classification of man. It is a review of different interpretations of Man's position in the animal world.

Musical Styles and Anthropological Groupings Among the North American Indians. GEORGE HERZOG, Indiana University.—The concepts of "style" and "type" with reference to musical and ethnomusicological material are discussed. Many factors and features are often presented in tribal styles. Because of the difficult task of the analyst, and because even today the music of some large areas is hardly known, it is not feasible at this time to present a musical map of aboriginal North America. No comparison can be made with the maps of culture areas produced by cultural anthropologists or with the maps of liguistic family-relationships. Instead, some examples will be cited from the musical picture to illustrate the extreme usefulness of such data both in connection with the descriptive cultural typology and in the reconstruction of the gensis and growth of aboriginal North America. This is one of the constant aims of the American anthropologist.

Origins of the Indians of the Middle Mississippi Area

Georg K. Neumann, Indiana University

In agreement with the concept of a relatively late settlement of the New World by American Indians, the great regional diversity in physical appearance has generally been explained in terms of migrations from northeastern Asia. With the development of more sensitive methods of dating archaeological remains, the first appearance of the Paleo-Indian in the New World has been pushed back into the neighborhood of twenty-five thousand years ago. The increase in time-depth allows for a much greater possibility of such factors as genetic drift and selection in the adaptation to different environmental conditions to become operative in the racial differentiation of populations in various geographical areas. This conceptual change obviously has a profound bearing not only on the number of migrations but also on the racial classification of the aboriginal inhabitants of the entire New World. In this paper I would like to present a modified framework for a classification and indicate how it applies to the Muskogean-speaking Indian tribes of the Middle Mississippi area and the South.

In order to obtain solutions to problems of the history of ethnic groups that will withstand the critical examination of the bioanthropologist and archaeologist, the data must satisfy a number of conditions: (1) it should cover a sufficiently wide geographical range, (2) it should represent the necessary time perspective, (3) it should deal with series that constitute statistical samples, and (4) it should involve only populations which really formed inbreeding entities. Needless to say, these four conditions are difficult to fulfill when one deals with sporadic archaeological materials. Whether these conditions are satisfied or not, it is obvious that if we deal with problems of such temporal and geographic scope that the units on a varietal level of differentiation are going to be dynamic, that is, ever changing in their gene frequencies controlling their morphological characteristics, rather than static entities. The relative stability or instability of any particular population depends on such factors as isolation, population size, genetic drift, various forms of selection, and the nature of new groups entering the area.

When one deals with an area as large as continents it is convenient to subdivide the material according to not strictly taxonomic levels of differentiation—levels into which the temporal factor also enters. Analogous examples are the grouping of species into series, or the grouping of archaeological materials attributable to Paleo-Indian, Archaic, and Food Producing peoples. Similarly, I like to speak of varieties or races within the Mongoloid subspecies of Man that can be dealt with in terms of (1) earlier phylogenetically more primitive *Paleoamerind*, (2) more recent derived or modified *Mesoamerind*, and (3) most recent immigrant *Cenoamerind* series. As one approaches the historic present, tribes on each of these levels may be contemporaneous, for it has been established that groups that have undergone only minor differentiational changes have survived as isolates in marginal or refuge areas.

Among the North American Indian—a more or less geographical

concept—such varieties as the Southwestern desert or Otamid variety, the Southwestern Basketmaker or Ashiwid variety, the Eastern Woodland or Lenid variety, and the Southern Archaic or Iswanid variety, would fall into the Paleoamerind series. The Classical Maya and related Central American groups or the Uinicid variety, the later Great Basin Shoshonean tribes or Nootchid variety, the Southeastern or Walcolid variety, the Central Algonquian or Ilinid variety, and the Plains Siouan or Dakotid variety would fall into the derived or Mesoamerind series. Finally, such groups as the Northern and Southern Athabascans or the Deneid variety, and the Eskimo or Inuit variety would fall into the Cenoamerind series.

When this concept is applied to an ethnic group such as the Amerindians who were speakers of languages of the Muskogean linguistic family the problem becomes very complex. The primary grouping is taken at the historic time level and it becomes necessary to work backwards to determine the correlation between the various tribal groups of the area and recognized archaeological entities. These archaeological entities must be accepted by the bioanthropologist in the determination as to what constitutes a particular series. If the series is morphologically homogeneous enough, that is, exhibits reasonably low variability, it can be accepted as a group that has been inbreeding long enough to become stabilized. At the same time we would not get very far if we did not combine our inquiry with an inductive approach. We have to know the number and variability of the more ancient groups, not only of the area under immediate consideration, but also those groups of neighboring areas that may have entered the region and influenced the local population.

Although we have very little information dealing with the Paleo-Indian of eastern United States, depending on a number of isolated finds without precise cultural associations, we are more fortunate when we come to the hunting and gathering peoples on an Archaic level. Here we have well-documented skeletal series found in their radiocarbon dated archaeological contexts. According to the best evidence available, differentiation from a common Paleo-Indian ancestor into a southern Archaic Iswanid and a northern Archaic Lenid variety was well on its way by about 6000 B. C. The Paleoamerind, Early Archaic ancestor of both groups can in all probability be linked with a Gulf-Algonquian linguistic forebear, who under conditions of relative isolation gave rise to the Muskogean and the Algonquian linguistic groups in the Middle Mississippi and Great Lakes areas. Adequate Middle Archaic level skeletal series in both areas are clearly differentiated into Iswanid and Lenid varieties, respectively, by about 4000 B. C. The Archaic Indian Knoll series from Kentucky, and the Old Copper culture-Early Woodland series from Wisconsin, Illinois, Indiana, and Ohio furnish classical examples.

On the basis of evidence from the Modoc Rock Shelter in southwestern Illinois, which provides a continuous occupational record from 8000 B. C. to 1000 A. D., there occurs a gradual change, involving increase in size and brachycephalization, in the Middle Archaic population. This marks the origin of a derived Mesoamerind population and the origin of the Walcolid variety that largely became associated with the development

of Middle Mississippi and related cultural manifestations and languages which have been placed into the Muskogean linguistic family. Parallel changes are to be found in the taller, more robust Lenid population. Thus, Early Hopewellian skeletal material is practically always Lenid, while Middle Hopewellian material exhibits changes. Before the end of Middle Woodland times some of the Lenid groups migrated to the East to give rise to the relatively unaltered Eastern Algonquian dolichocranial population. The Delaware are an example. Along the southern margins of the Great Lakes area other Lenid entities gave rise to the brachycephalized Adena population, and during the latter phases of the same Middle Woodland level, the Lenid groups that remained behind became the Illinid variety, largely associated with Late Woodland and Upper Mississippi archaeological manifestations—tribes that mostly speak Central Algonquian languages.

By A. D. 900 the Middle Mississippi Phase people are well differentiated, and subsequently become predominantly Walcolid in all southern Illinois and Tennessee-Cumberland Aspect sites. The Upper Mississippi, Fort Ancient Aspect peoples of southeastern Ohio and Kentucky are, like the earlier Adena people, transitional between Ilinid and Walcolid.

Finally, a relatively late derived or Mesoamerind variety developed in the northeastern Plains area. This is the Dakotid variety, largely of Dénéid derivation. Probably not much earlier than A. D. 1200 groups predominantly of the Dakotid variety came into contact with the Caddoan horticultural village tribes that pushed up the Missouri and its branches. Farther to the east in Iowa, southwestern Wisconsin, and northwestern Illinois the Dakotid variety came into contact with Central Algonquian groups, who readily took over the Upper Mississippi culture of their Chiwere Siouan neighbors.

In conclusion it may be stated that in the past the origin of the bearers of the Middle Mississippi culture, which I demonstrated to be highly correlated with the Walcolid variety (Neumann, 1952), was generally explained on the basis of an advent of a new people into the Middle Mississippi geographical area. It was believed to involve the replacement of earlier populations by "more Mongoloid" immigrants from northern Mexico. It is without question that a number of cultural contacts can be demonstrated, but there is little bioanthropological evidence for any large scale migration. Knowledge of the archaeological and racial history of the Indians of eastern United States has now advanced to such a point that all the hypotheses advanced in this paper can be substantiated by data collected on well documented cranial series.

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Diagnostic Morphological Traits for the Walcolid Variety of American Indians

Holm Wolfram Neumann, Indiana University

The ultimate purpose of this study is the delimitation of a racial group on a varietal level. The Walcolid variety was selected mainly because of current interest in the Indians associated with the Middle Mississippi cultural Phase and because measurements and observations of these series are numerically the best represented in the files of the Laboratory of Bioanthropology of Indiana University. In 1952, Neumann (1) presented a metric and morphological description of the variety using a group of forty-five undeformed adult male skulls of the Spoon River Focus as a type series. The present study differs first of all in scope in that four geographically separated series have been included. These are the Spoon River Focus series of forty-five skulls from central Illinois, twenty-one skulls of the Aksarben complex of eastern Nebraska, eight skulls of the Upper Republican manifestation from the same state, and twenty-four from the Angel Site in southern Indiana. Temporally the four archaeological series fall into a time span of roughly three hundred years, that is, 1200 to 1500 A. D. Secondly, this study differs in that it is entirely on a morphological basis, as it was felt that this approach would come closer to expressing genetic differences.

The first step in the analysis consisted of determining which of the forty-six morphological traits considered can be regarded as typical of the Walcolid variety as a whole. This involved a comparison of the frequencies with which the traits appear in varieties of adjacent areas. Thus if one of the four groups differs widely in a particular trait from the other three, and if this difference can be explained in terms of admixture from a known neighboring variety, it was excluded from the total group average. In this way the ancestral or unmixed type can be reconstructed. Each trait is, then, taken separately.

Comparisons revealed: (1) that the specific trait may exhibit a uniform frequency distribution in the four groups, (2) that the frequencies of one of the groups may be aberrant in the direction found in a neighboring variety, and (3) that due to overlapping with neighboring groups or due to smallness of the sample, the trait is adiacritical. It is only after broader comparisons with other varieties—and here I use the four varieties established by Neumann (1952) as a basis—that one can determine which of the traits are actually diagnostic for the group as a whole.

An example of a uniform trait frequency distribution for the four Walcolid series is that for the development of the parietal eminences. All four groups are close to 100% for the medium category. But since about the same condition is found in Early Woodland series (Lenid variety) of the Great Lakes area, and in Archaic series (Iswanid variety) from Kentucky, which may be ancestral to the Walcolid variety, this trait has no diagnostic value as far as the Iswanid-Walcolid and Lenid-Walcolid pairings are concerned.

Parietal Eminences

	small	*medium*	*large*
Spoon River Focus	4%	94%	2%
Nebraska	0%	100%	0%
Upper Republican	0%	100%	0%
Angel Site	0%	100%	0%
Walcolid variety	2%	98%	0%

Another uniform distribution is that for size of the nasal bones. Here again the frequencies for the medium category range in the four series from 90 to 100%.

Size of Nasals

	small	*medium*	*large*
Spoon River Focus	10%	90%	0%
Nebraska	0%	95%	5%
Upper Rebublican	0%	100%	0%
Angel Site	0%	100%	0%
Walcolid variety	3%	96%	1%

In contrast to the preceding, however, this trait has diagnostic value in a Dakotid-Walcolid pairing, for in the Plains area the "large" category may rise to eighty percent. In other words, great uniformity of a morphological trait does not necessarily make it diagnostic for the group.

In some cases admixture may be indicated when the frequencies of a trait are aberrant in the direction found in a neighboring variety. Lambdoid flattening furnishes an example:

	Absent	*Small*	*Medium*	*Pronounced*
Spoon River Focus	49%	46%	5%	0%
Nebraska	90%	10%	0%	0%
Upper Rebublican	86%	14%	0%	0%
Angel Site	83%	13%	4%	0%
Walcolid variety average	77%	21%	2%	0%
Typical Walcolid average	87%	12%	1%	0%
Typical Lenid average	7%	13%	67%	13%

Although there is some overlapping of frequencies in the comparison of the Walcolid variety and the Lenid variety (Early Woodland groups from Wisconsin and Illinois), bipolarity is obvious. The virtual absence of the feature in one variety and the presence of a medium amount of flattening in the other makes this a diagnostic trait, which in combination with other morphological characteristics allows one to make a clear distinction between the two varieties.

The above table also illustrates how we may reconstruct the ancestral or typical Walcolid type. The Spoon River Focus people, who were in contact with a Lenid population, should be excluded from the typical Walcolid average. Combining the remaining three series the Walcolid-Lenid difference is accentuated.

Finally, one may consider morphological traits the frequencies of which are adiacritical. An example is brow ridge size. The frequencies cover the whole range of the distribution from small to large, do not exhibit polarity in any of the series, and overlap largely in varietal pairings. The percentages are the following:

	small	*medium*	*large*
Spoon River Focus	27%	42%	31%
Nebraska	43%	43%	14%
Upper Republican	24%	38%	38%
Angel Site	26%	39%	35%
Walcolid variety average	30%	40%	30%

Omitting the traits that deviate from the general trend of the variety, we can now describe and delimit the Walcolid variety on a morphological basis:

Trait Frequencies for the Walcolid Variety

	Trait	*Percent*		
1.	Muscularity	sm 1	m 55	l 44
2.	Vault form	ell 2	ov 83	spr 15
3.	Brow ridge size	sm 30	m 40	l 30
4.	Glabellar prominence	sm 38	m 42	l 20
5.	Frontal slope	sl 23	m 76	l 1
6.	Frontal eminences	sm 50	m 50	l 0
7.	Median crest	abs 94	sm 5	m-l 1
8.	Frontal breadth	sm 13	m 72	l 15
9.	Sagittal elevation	abs 82	sm 17	m-l 1
10.	Parietal eminences	sm 2	m 98	l 0
11.	Lambdoidal flattening	abs 7	sm 13	m 67 p 13
12.	Occipital curve	abs 0	sm 54	m 46 p 0
13.	Occipital position	hi 0	m 100	low 0
14.	Occipital breadth	bun-n 17	m 77	br 6
15.	Temporal fullness	flat 0	sm 32	m 54 l 14
16.	Mastoid size	m 29	l 60	vl 11
17.	Styloid process	sm 56	m 35	l 9
18.	Mandibular fossa	sm 0	m 71	l 29
19.	Tympanic plate	thin 88	m 12	thick 0
20.	Platybasia	abs 98	pres 2	
21.	Orbit shape	obl 3	rhom 61	sq-rd 36
22.	Orbit inclination	sm 39	m 54	p 7
23.	Size of Zygomatics	sm 4	m 43	l 50 vl 3
24.	Suborbital fossa	abs 9	sm 53	m-dp 38
25.	Lateral projection of zygomatics	sm 1	m 28	l 71
26.	Anterior projection of zygomatics	sm 6	m 80	l 14
27.	Nasion depression	abs 19	sm 51	m-dp 30
28.	Nasal root height	low 4	m 90	hi 6 vhi 0
29.	Nasal root breadth	sm 11	m 83	l-vl 6
30.	Nasal bridge height	low 4	m 85	hi 11 vhi 0
31.	Nasal bridge breadth	sm 6	m 87	l 7
32.	Nasal profile	str 0	scv 100	cv 0
33.	Size of nasals	sm 0	m 100	l 0
34.	Anterior nasal spine	sm 52	m 45	l 3
35.	Nasal sills	abs-dull 33	m 54	srp 13
36.	Subnasal sulcus	abs 72	sm 15	m-pr 13
37.	Face size	sm 1	m 66	l 33
38.	Midfacial prognathism	abs 50	sl 46	m-p 4
39.	Alveolar prognathism	abs-sl 38	m 58	pr 4
40.	Total prognathism	abs-sl 49	m 48	pr 3

41.	Palate shape	par 92	hyp-ell 5	up 3	
42.	Palatine torus size	abs 70	sm 26	m-l 4	
43.	Size of mandible	sm 6	m 53	l 35	vl 6
44.	Chin form	md 24	bi 76		
45.	Chin projection	neg 12	neut 54	sm 11	m 23
46.	Eversion of gonial angles	abs 48	sm 30	m 17	pr 5

The following abbreviations are used above: abs—absent, pres—present, sl—slight, sm—small, m—medium, l—large, vl—very large, p—pronounced, hi—high, vhi—very high, dp—deep, neg—negative, neut—neutral, srp—sharp, str—straight, scv—slightly concave, cv—concave, md—median, bi—bilateral, sq—square, rd—round, ov—ovoid, ell—ellipsoid, spr—spheroid, rhom—rhomboid, par—paraboloid, hyp—hyperboloid, obl—oblong, bun—bun-shaped, n—narrow, br—broad.

As has been pointed out above, diagnostic morphological traits are relative, that is, depend on what particular pair of varieties are compared. At this time a Lenid-Walcolid comparison would perhaps be of greatest interest. The relationship is perhaps something like an avuncular relationship. The Lenid variety is probably the ancestral Paleo-Indian type. In the South the Iswanid variety differentiated approximately around 8000 B. C. in Archaic times, while the Lenid variety persisted relatively unchanged in the northeastern woodland area. Subsequently, sometime around 3500 B. C., further changes occurred in some Archaic Iswanid populations, which resulted in the differentiation of Walcolids as we find them in early historic times. This evolution is paralleled by a linguistic development from Algonquian-Gulf to separate Algonquian and Gulf language families.

The morphological characteristics in which the Northern Archaic and Early Woodland Lenid peoples differ most markedly from the Middle Mississippi Walcolid people seem to be the following. In cranial vault form the Lenid variety tends toward exhibiting more elliptical contours, while the Walcolid variety tends to broader ovoid and spherical forms. Development of more medial frontal cresting, greater sagittal elevation and lambdoid flattening, greater occipital prominence, lower occipital position, larger styloid processes, more oblong orbit form, greater anterior projection of the zygomatic bones, a more elevated nasal bridge, a somewhat larger face, and greater chin prominence, distinguish the Walcolid from the Lenid variety.

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More Findings at the Serpent Mounds Site, Rice Lake, Ontario

Richard B. Johnston, Indiana University

In a previous paper (1) the Serpent Mounds Site in Peterborough County, Ontario, was briefly described, mention was made of known previous work there and the results of investigations of the site by the Royal Ontario Museum between 1955 and 1957 outlined. During that period, excavation was concentrated in and around the eastern end of the 194 foot long Serpent Mound and in initial examination of adjacent Mound I. An exploratory excavation was also reported in shell midden deposits near the mound group on the shore of Rice Lake. These investigations revealed a dozen burials in the Serpent Mound, most without grave goods, and a mass burial area containing seventeen individuals in the central portion of partially excavated Mound I. Testing in the shell midden had indicated that more extensive excavation should be done in that feature.

In 1958 and 1959 seventy-five additional 5-foot squares were excavated in the Serpent Mound, excavation of Mound I completed and 112 squares excavated in the shell midden, while new work in other features has contributed to a more complete understanding of this site.

In 1958 (2) and 1959, work in the Serpent Mound has revealed thirteen additional undisturbed burials, several with grave goods of a sort and in quantities not previously encountered. Included among this number was Burial No. 28, fully excavated in 1958 after discovery late the previous year and one of the most important in terms of grave accompaniments. This was a flexed adult male in an oval pit dug in the original ground surface prior to mound construction. Arranged around the skull were unmodified mammal phalanges, fish bones and scales, fossils, concretions, five shell disc beads, the beak of the Common Loon *(Gavia immer)* and other objects. A carved stone effigy beneath the skull may represent a bird although this identification is speculative. Burial No. 60, a juvenile, was likewise interred in a sub-floor pit where traces of ash or wood remains were found over the flexed burial itself and along the pit sides. A trianguloid projectile point was recovered from amongst the ribs. Grave goods had also been placed with flexed Burial No. 56 which, together with Burial No. 55, had been placed on the old ground surface and covered with mound fill. A turtle carapace (the Painted Turtle *Chrysemys*), a fossil coral, a fragmentary mink skull *(Mustela vison)*, a portion of the beak of a Loon *(Gavia immer)* and forty-one shell disc beads were found immediately around the skull.

Two additional burials were discovered in 1958 in sub-floor pits (Burial Nos. 34 and 41) but both lacked grave goods. Other burials, two primary and two secondary, occurred in the fill of the mound, but none had accompanying artifacts.

The bones labeled Burial No. 31 were the disturbed remains of at least three adults redeposited in the bottom of a recent intrusion. Throughout the mound, especially in the upper levels, extensive disturbances have been encountered and, in fact, during the 1958 season, only about 25% of the area forming the crest of the mound was found to be

undisturbed. For this reason it has been difficult if not impossible at times to find evidence relating, for instance, to the question of whether the mound was built in a relatively short span of time or accretionally over a longer period.

In 1959, the certain prospect of continued excavation in disturbed fill, if work was resumed in the eastern portion of the Serpent Mound, led to a shift of attention to the western end of the Mound, the so-called tail. Here, also, it was disappointing to find several old diggings, the backfill of one of which contained a broken glass bottle and a large quantity of jumbled bones representing an unknown number of burials, but the present investigation did discover four burials *in situ*, three of which contained definite grave inclusions.

Burial No. 61 was found in the carried earth of the mound only eight inches below the surface. This was a partial cremation of a child near which three copper beads had been deposited. Burial No. 62, an infant, was also a partial cremation in the fill of the mound. Three hundred and seventy whole shell beads, of the disc and barrel variety, were uncovered in the vicinity of the neck, in juxtaposition in the ground as if strung on a necklace. In fact, a few small carbonized fragments of cordage were found running through the perforations of the beads. Burial No. 62, largely but not entirely disarticulated, occurred in mound fill without definite association with artifacts. One and a half feet below, flexed Burial No. 64, illustrated in Figure 1, was found in a sub-floor pit. This individual, a young adult male, had been partially covered with wood which extended over a considerable portion of the pit. Most notable of the grave goods was a polished stone object, plano-convex in outline and some twelve inches in length, found in the knee region. This might be called a double-bitted adze or a "pick."

Thus, in 1958 and 1959, excavation in the Serpent Mound has revealed thirteen undisturbed burials, five interred in sub-mound pits, two on the old ground surface and six at various levels in the mound fill. Grave goods accompanied three of the pit burials, one of those on the old sod level and two of those encountered in the carried earth of the mound. All total, the current work, after excavation of slightly more than half of the Serpent Mound, has produced twenty-five undisturbed burials and approximately twice as many disturbed burials as represented by jumbled bone in the backfill of intrusions.

Radiocarbon analysis has been made by the University of Michigan Memorial-Phoenix Radiocarbon Laboratory on two small carbonized logs associated with partial cremation No. 4 from the Serpent Mound. The date derived (M-850) was 1830±200 (BP 1958) or a date of 128 A. D. (3). The wood which composed the sample has been identified as a member of the white pine group, most likely *Pinus strobus*.

In 1957 a trench was extended through shallow Mound I. In the central portion of the mound a mass grave was encountered which, as exposed in the limited excavation of that year, contained seventeen individuals. In 1958, further examination of this feature resulted in a final count of twenty-nine burials. Six were primary interments in the lower portions of the long common grave around and over which were placed twenty-three secondary burials in ossuary fashion. One total

Figure 1. Burial No. 64 partially covered with wood remains. Note "pick" in knee region. Six inch arrow points north.

cremation is included, also apparently secondary judging from the absence of ash and other evidence of firing among the calcined fragments. None of the burials had been furnished with grave goods although some refuse, including pottery fragments, was recovered from the fill of the mound, only about a foot and a half deep at the high point at the center of the structure. What little cultural material was found would associate Mound I with the Serpent Mound.

Major excavation was undertaken in 1958 and 1959 in the shell deposits along the shore of the lake below the mound group, with the result that a considerable quantity of material, notably pottery, has been recovered. No burials have been encountered in the shell deposits. Only a few projectile points have been recovered but a number of ground stone objects, chiefly adzes or adze fragments, have been taken from the shell layer. Bone pins and awls, one of which was fashioned from a bear radius, have been relatively abundant in the midden which contains large quantities of animal and fish bone. Two bear canines, one drilled at the tip of the root, one unilaterally and one bilaterally barbed bone harpoon have come from the shell deposit. Perhaps the most important refuse from this former habitation area is pottery, which has been found in increased amounts in the most recent season of work. It is expected that eventual statistical analysis of the enlarged ceramic sample will confirm previous tentative placement of the bulk of the ware in the Middle Woodland horizon. Some sherds can be assigned to later periods, up to and including the Iroquois. The only whole vessel recovered was a toy perhaps an inch and a half in height, complete with dentate impressions. A charcoal sample adequate for C14 analysis was collected from the lower level of the midden but its age has not yet been determined. Another charcoal sample, as yet undated, has also been secured from the Serpent Mound.

Two hundred and forty feet of exploratory trench south of the Serpent Mound has shown this area to be virtually sterile but excavation in two small depressions about a hundred and seventy feet north of the mound group has proven them to be burial pits. Depression No. 1, excavated in 1958, contained eight skulls and some post-cranial elements but not enough for eight individuals. A side notched projectile point was found in the pit fill but cannot, beyond this fact, be associated with the burials. Another depression, No. 2, was investigated in 1959 and found to contain twenty-four individuals, as reckoned by a count of the skulls. As in Depression No. 1, no articulation of the bone content was noted. Depression No. 2 measured approximately four by five feet in plan and two feet deep. The twenty-four bundle-like burials, occurring along the pit sides and bottom, appeared to line the pit in a complex overlapping fashion. A damaged polished stone adze was found in the pit fill as were a few sherds. At least one of these tenuously associated sherds, a rim, is of Late Woodland origin. However, present evidence does not allow a clear statement as to the cultural provenience of these burials in pits north of the mound group.

The pottery, especially, and other materials recovered at this site indicate an initial occupation by a Middle Woodland people. The sherd sample, recovered primarily from the shell midden, seems generally

parallel to that taken by Ritchie from a comparable midden on nearby East Sugar Island (4). Both collections contain types included by Ritchie and MacNeish (5) in the general category of Vinette 2 wares. The occurrence of this ceramic complex and other materials at Serpent Mounds site, in association with a carbon 14 date of 128 A. D., would suggest Point Peninsula 2 affinities. Subsequent occupation is demonstrated by the finding of Glen Meyer and Owasco-like wares and a few Iroquois sherds. It is hoped that final analysis of the findings at the Serpent Mounds site and its placement in proper prehistoric context will form a substantial contribution to the archaeology of the region. What is needed in the Northeast to further clarify and expand knowledge of the now imperfectly known Woodland stage is careful excavation of new and undisturbed sites.

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Towards the Estimation of Prehistoric Populations

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Introduction

In the course of studying archeological data in a small river basin on the Chattahoochee River in Alabama and Georgia, it seemed desirable to the present writer to achieve some way of representing, in an objective fashion, the relative use of the Oliver Basin by the several different prehistoric cultural groups through time (3). The following device was created to facilitate this, and is presented herein with additional discussion and evalution of its value as a tool of population estimation.

Prior efforts in this area have been of two types: 1) gross figures for entire "cultural periods" and 2) population estimates for individual sites. The former have all been subjective impressionistic guesses somehow based upon total number of sites per period with consideration of site size and intensity. Willey provides an example of such in his work on the Florida Gulf coast (4). Estimates of the latter type, for individual sites, have generally tended to be more objective and more frequent. Hooton made an estimate of the population at Madisonville through the number of skeletons found (1). And also many Anasazi sites in the American Southwest have population estimates based upon the total number of dwelling units at any one site. The present paper however, refers to the former category and attempts to provide a more objective method of estimating population per "cultural period" through time.

Method

In essence, the method utilized by the present author is based upon the assumption that the frequency of artifacts per cultural period should in some fashion reflect intensity of use of an area, and that intensity of use can be inferred to mean population.

It was assumed that the total universe (the Oliver Basin in this case) was well sampled in both space and time, i.e., all major cultures were represented, and over 50 sites with 129 components were located in this very small river basin. It would seem likely that the number of components of each cultural period properly weighted would reflect the use by the occupants during each period. By a process of double weighting as follows, an estimate was achieved.

1) Component Use Intensity: Each component (a temporally limited, culturally consistent occupation at any one site) within a "cultural period" (usually a focus or aspect level cultural unit) was given a numerical value, one through three, depending upon amount of cultural material that occurred at the component. If, for instance, just traces of a particular pottery type were found, then a value of "one" was given, but if considerable pottery and/or other artifacts occurred, then a value of "three". A policy followed however, was that in the earlier ceramic contexts fewer sherds would be given greater value than in later contexts, since it is a good assumption that there was

an absolute increase in the use of pottery within the later periods. This was demonstrated for a nearby area by the present writer (2).

2) Temporal Weighting: A chronology was erected for the entire prehistoric occupation of the Oliver Basin, and then broken down into 250 year time units (1 time unit equals 250 years), and the time units per cultural period calculated, i.e., the duration of each cultural period; these were then rounded to the nearest whole time unit.

3) All the weighted components are added together for each individual period, and then divided by the appropriate number of time units. The resultant number is designated the Use Intensity Index. The weighting of components reflects the intensity of use at the individual sites, while the temporal weighting reduces cultural periods to a par, so that longer periods are not overly represented simply due to the longer time interval in which they occupied the area. In formula this amounts to:

$$\frac{\Sigma C_w}{t} = UI$$

where

Σ = summation
C_w = Weighted components of one "cultural period"
t = time units (1 = 250 years)
UI = Use Intensity Index for one "cultural period"

Plotting the resultant Use Intensity Indices for all the cultural periods represented within the Oliver Basin in proper time sequence provides the accompanying Curve of Occupational Intensity (Fig. 1). Here

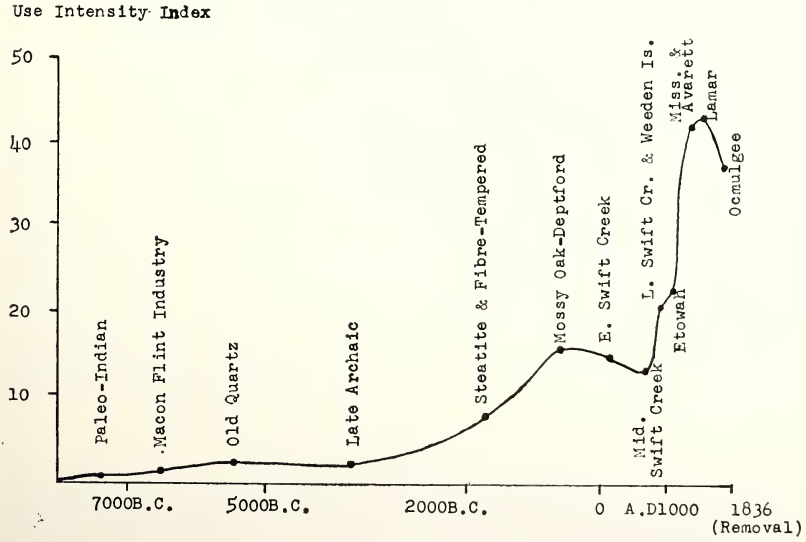

Figure 1. Curve of Occupational Intensity, Oliver Basin (Ga.-Ala.)

the Index is shown on the y axis for each period in its proper time sequence, and the time unit allotment is retained for the x axis. In cases of temporal overlapping of cultural periods, the indices for these overlapped periods are combined for plotting purposes. Groups so combined did appear to occupy the same time intervals. It is this curve (Fig. 1) that the writer would imply is a model of the population pattern of the Oliver Basin.

Critique of Method

Firstly, there may be some doubt that this actually reflects population. It certainly reflects the "intensity" of use by the several cultural groups, but whether this may be considered to mean population as well is a moot point. The writer suspects that such an inference can be made, though local situation should be considered. In the present case, the Oliver Basin, the area occurs within the fall line of the Chattahoochee River, a unique environment which resulted in most sites being small campsites. In this case occupation would have been non-continuous and intermittent; but nevertheless the relative size of communities using the Basin is implied, and hence population through time.

The area of study utilized in this method ideally should be a natural area of sufficient diversity as to be able to support all types of economies utilized by the prehistoric inhabitants, or barring this, recognition of the fact that the area of concern would not be conducive to certain economic bases, and hence the cultures adhering to such an economy would not be well represented. In the present instance, the Oliver Basin included very few hilltop areas and it is entirely possible that certain groups (especially early hunting groups) would have preferred hilltop locations.

But the matter of area may be one of the more important assets of this tool: in any given natural area, what particular prehistoric groups were utilizing the area, and therefore what economic inferences can then be made. In the Oliver Basin, the falls area was undoubtedly a good locale for fishing, and therefore we may assume that any group using the basin to any extent was probably attracted by this feature. So then, the selection of area hinges upon the investigator's interest, either in the overall picture or from an ecological point of view. In the present case little choice was available since it was a matter of salvage archeology, but nevertheless, a fascinating ecological situation was present.

The graphic representation of this method could be debated, but the writer finds the present method preferable. A curve is superior to a bar graph, since there is probably more continuity present in the area than not, and the plotting of a point at the midpoint of the "cultural period" is more in keeping with cultural dynamics: a particular cultural unit does not spring from nothingness full-blown, but is much more likely to develop gradually and subside gradually, barring outside interference, i.e., an approximation of the normal curve; hence the curve form is more amenable to the present purpose.

A far more telling weakness lies in the fact that this is still a subjective mode of estimating population in several respects. While it contains a certain aura of objectivity, in actuality, the weighting processes are still much too subjective. In the present case, it is not possible to

segregate all artifactual material into mutually exclusive "cultural periods," particularly for plain-surfaced pottery types and flint artifacts. Also, excavated sites and surface collections were combined, and in this area it is frequent that excavations reveal the presence or greater frequency of components not suspected from surface indications. A separate plotting of excavated sites only presents a slightly different curve, but for the sake of greater sample size the total plotting (surface and excavation) was retained. In short, the artifact weighting could be greatly skewed through these mechanisms.

Likewise, the chronology utilized by the writer would probably be debated by other workers in the area to greater or lesser extents, so that a possibility for error exists in this weighting process as well.

In brief, the writer is not satisfied with the present component weighting, and would much prefer a more objective method. Unfortunately, in the present example nothing more objective is possible, since all artifacts cannot be separated into mutually exclusive cultural units. But if such were the case, it should be possible to use an absolute weighting mechanism. Possibly by using a standard unit (several ten foot square levels or surface collections only) and computing artifacts per unit, a completely objective tool for weighting could be achieved. But a prerequisite is that all artifacts be assignable to one or another cultural group, with no appreciable residual category, such as was present in the Oliver Basin and prohibited the use of more objective weighting.

In addition though, some manner of graduated correction factor should be utilized to compensate for the fewer potsherds per person in the earlier ceramic periods. At least in the Southeast it is apparent that while population is increasing only gradually, use of pottery increases more sharply.

In so far as the weakness of the temporal weighting is concerned the writer is optimistic that more Carbon-14 dates will make archeologists more and more sure of their chronologies, and so this will not be an insurmountable objection.

Finally, with a method such as this, some manner of independent verification of the results is needed. By taking some restricted, well studied natural area of the American Southwest, preferably within the Anasazi region, an independent check on the present method could be accomplished. In this area, at least throughout most of the ceramic periods, stone dwelling units were constructed, and by tabulating dwelling units per period within the area and plotting these on an appropriate time scale, and here dendrochronology provides absolute dating, and then running independently the presently suggested method upon the same area, an adequate check on reliability could be achieved. If the present method is accurate, then parallel curves would be prescribed for the area by the two different methods.

Evaluation

The presented method for estimating prehistoric population, while incorporating many advantages over the few previous attempts, still contains much subjectivity. Suggested changes in the method, and independent cross-checking would minimize lack of confidence in the method.

However, the example utilized is not conducive to such modifications and checking.

The writer feels that the method has, despite present flaws, much to offer the field of archeology. In the example presented, not only is population reflected, but the economic bases of these populations. A least there appears to be a remarkable congruence between the dominant economic pattern and the population it was able to support: in essence, three curves are present within the one curve for the Oliver Basin (Fig. 1). A) A long low curve which corresponds with the early Hunting tradition of the area; B) a moderately peaked curve in the middle, which portrays the increased efficiency that a gathering economy allowed in this area; and finally C) a high peaked curve suggestive of the horticultural capture of this region, and the much greater efficiency of this economy. Incidentally, this demonstrates the fallaciousness of the Malthusian doctrine, that while population increases geometrically, production increases numerically; to the contrary, the Oliver Basin Curve of Intensity demonstrates that population is contingent upon economic increase, and that in this instance at least, production was increasing at an almost geometric rate.

Furthermore, the writer would expect that given any absolute population figure at any point upon the curve, then by extrapolation, the population for the entire continumn could be readily gotten. An absolute population figure could be had either from historical sources, or again from computations at individual sites such as mentioned in the introduction of this paper.

In sum then, a graphic tool with multiple uses could be added to the archeologist's kit of analysis, if the presently described method of population estimation is further refined.

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Some Aspects of Pueblo Native Religion

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Introduction—The pueblo under scrutiny here is Tesuque. Religion at Tesuque acts as a strong integrading factor in their culture. It serves as a unifying force which permeates practically every aspect of their way of life. The culture of Tesuque becomes more intelligible with a better understanding of the religion and this fact, coupled with their profound secrecy of everything religious, makes field work on the pueblo all the more difficult.

The secrecy on matters religious is mainly limited to the native religion. Along with the practice of native religion, the Tesuque practice Catholicism, and one family belongs to the I Am religion. These religions, though usually practiced independently of each other, have over-lapped in many instances. This paper will deal only with the native religion.

Native Religion—The author was never told anything in particular about the native religion. To keep in the good graces of his hosts, he had to avoid delving deeply into any discussion concerning their religion. However, no anthropologist who has lived at Tesuque can completely escape learning something about the native religion, just as no anthropologist can ever make a complete study of Tesuque's native religion. Though the degree of conformity may vary, every adult at Tesuque is a religious conformist, and participates in the religious life of the community. All Whites, Spanish-Americans, and non-Tesuque Indians are excluded from all native religious ceremonies. However, in certain religious ceremonies, the Tesuque assist, or seek assistance from, other pueblos. Such a relationship is especially strong with Nambe Pueblo, a Tewa speaking pueblo like Tesuque.

Elderly men play the dominant role in the native religion of Tesuque. These are also the leaders found in the secular hierarchy. They know and guard the esoteric aspects of their religion. The knowledge of these aspects is exclusively in their own possession by virtue of the office they hold in religious societies. Though there is complete secrecy as to these societies and their functions, it seemed apparent that the men powerful in these societies were also officers in the secular hierarchy. They were respected and feared not only for the offices they held but also for the knowledge they possessed in the capacity of "priests."

The Caciques are the religious heads of their moiety throughout their term of office, and the secular heads of the whole pueblo, during that period of the year when one of them wields the reins of government. It is the duty of a Cacique to be a wise leader in matters both religious and secular, and he is the custodian of religious paraphernalia. In the performance of his duties he is helped by other religious officers, often referred to as "elder brothers." In conjunction with these officers, and the efforts of the pueblo at large, it is the Cacique's duty to insure divine blessing on his people and to make the forces of nature help the Tesuque Indians through faith, prayer, and ritual. Though in this respect the Tesuque act as a group, the distinction is made between the officers and the rest of the Tesuque on a basis similar to that between an expert and

a layman. The Cacique and his officers, due to their knowledge and experience are considered experts in the field of compelling or supplicating nature to fulfill the desires of their people.

Historically, the religion of Tesuque derives its major interest from the nature of the environment. Of chief importance in this environment is water, or rather the lack of it. In the Pueblo area in general, there are only a limited number of rivers and streams, and few of them flow permanently. There are hardly any fish in their environment and game was so scarce that it could not be relied on. Since Tesuque once depended almost entirely on agriculture and since corn, before the arrival of the white man, was more than ninety per cent of their food, the lack of water for agriculture is obtrusive in many of their religious beliefs, rituals and superstitions. With starvation constantly at their door, it is not surprising that the major concern of the Tesuque, and the principal aspects of their religion, should cluster around their main economy—agriculture; their major daily food—corn; and that which makes this possible—rain, which in turn came from the sky, clouds, and thunder. Rather than leave their peaceful territory for more fertile and more hostile lands, the Tesuque, along with other pueblos, devised or acquired ingenious methods of irrigation and agriculture and placed faith in their religion to gain and retain the favor of nature and the elemental spirits. Those phenomena of nature which have movement—the clouds, the water, the sun, the moon, and especially the winds—are to them possessed by spirits.

Besides the dances, which are open to tourists, but may not be photographed, the Tesuque have secret ceremonies and dances, especially in the month of October. In this month, just prior to the end of the agricultural year, the pueblo of Tesuque is closed to all outsiders. Even those non-Tesuque Indians living at the pueblo are not permitted to take any part in the ceremonies that follow. The Tesuque themselves laugh about the dances open to the tourists, but the ceremonies performed secretly are held in great reverence and esteem.

The number four has a special significance in Tesuque religion where it is associated both with their dependence on the forces of nature in earlier times and the Catholic symbol of the cross in recent times. Perhaps it was due to the significance of this number that the Tesuque have taken kindly to the cross and used it so widely in their native ceremonies. Though the Tesuque recognize six major directions—North, South, East, West, Zenith, and Nadir—they think of the wind as coming from the four corners of the earth. The wind gains importance as one of the spiritual phenomena, for not only does it move, but one can feel it, hear it whistle, and even be destroyed by it. The number four is used most often in folk tales and is sometimes taken to designate "some" or "several" rather than the precise "four." It is believed that a promise becomes binding if repeated four times, and that the period of confinement should be at least four days as must be the period of mourning. A child is given an Indian name on the fourth day of its birth. In everyday life, the number four seems to have lost most of its religious significance, but the Tesuque admit that this is their most significant number, followed by number six, and that it has some symbolic value for them.

In the native religion, there is respect for land eminences. The author

was informed that such respect was derived from the proximity of these eminences to the "heavens" and thereby the source of rain. On a hill, west of the village, and southeast of the ball field, the author observed one such shrine. It consisted of an arrangement of white painted rocks, in the sign of a cross. Tesuque Indians, returning to the pueblo, often visited this shrine.

On the whole, the native religion emphasizes the group, rather than the individual; religious experience leading to a well developed ceremonial life, emphasizing ritual over belief. The tendency in these religious ceremonials is to identify the good of the individual with the common good. Hence, the native religion tends to draw the Tesuque people into a closely knit group and furnishes them with guidance and discipline.

The native religion also encompasses the realm of witchcraft, though there was no direct mention of it. However, during one discussion of sickness, the author was informed that sickness could be caused by some jealous person. The hospital could not cure it, and though in the past there were "doctors" on the pueblo who could cure it, a case of sickness from witchcraft would now be a hopeless case.

Conclusion—It is unfortunate that the time was not yet ripe for a detailed study of the native religion. In spite of their secretiveness, certain generalities regarding the native religion emerge. Native religion still plays a dominant role at Tesuque, and permeates their way of life to such an extent that it is difficult to draw a sharp and clear line between the religious and secular.

Two Forms of Iroquois Cousin Terminology and Their Functions

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This paper deals with two forms of Iroquois terminology. The Iroquois type of kinship system is generally regarded as a relatively stable type. Nevertheless, it is a type which is transitional to a mature or more highly developed form of kinship organization. The two forms of Iroquois terminology referred to are represented among two dialectically closely related Wintun societies in central California. One society has what may be called the normal or relatively stable Iroquois terminology. The other society also possesses Iroquois organization but utilizes kinship terms which makes it possible for the kinship system to change readily into either of two other types of kinship systems.

Iroquois cousin terminology is one of the six possible types of kinship systems or ways by which cousins can be classified in any society. Although the Iroquois type of cousin terminology is present among the Iroquois tribes, it is also found among many other societies throughout the world. Thus the name of a particular type of cousin terminology is derived from societies which were studied first, most intensively studied, or from areas over which a type is widely distributed. The type names are those defined by Murdock (1949) which are Eskimo, Hawaiian, Iroquois, Sudanese, Omaha and Crow. The presence of a specific type of terminology among widely separated societies does not imply historic connection or association of any kind.

Present day American society classifies its kindred in accordance with principles which place it within the Eskimo type of kinship system. Each type of cousin regardless of whether it is father's brother's children (Fa Br Ch), father's sister's children (Fa Si Ch), mother's brother's children (Mo Br Ch), or mother's sister's children (Mo Si Ch) are all classified together by utilizing the common English term "cousin." In the Hawaiian system all cousins are classified together as in the Eskimo system but each is also classified with and called by the same terms utilized for brother and sister. In Iroquois terminology a distinction is made between cross and parallel relatives. Cross cousins would be Mo Br Ch and Fa Si Ch since the relationship of mother to mother's brother and father to father's sister crosses or changes the sex line in the parent generation. Fa Br Ch and Mo Si Ch are termed parallel cousins because there is no cross or change of sex line. Iroquois cousin terminology can be defined as a type of kinship classification system in which cross cousins are classified together but they are not classified with parallel cousin or brother and sister. Distinction of sex may be made so that father's sister's daughter (Fa Si Da) is called by a different term than father's sister's son (Fa Si So). Yet, in so far as cross cousins, according to sex, are classified together in accordance with the definition, the system is termed Iroquois. In the Sudanese type of cousin terminology each cross cousin, such as Fa Si Da and Mo Br Da, is called by a distinct term and neither term is classified with any other relative. Sudanese terminology is frequently descriptive so that Fa Si So would be called simply father's-sister's-son.

The Omaha system like the Sudanese differentiate the two cross cousin and neither term utilized for a cross cousin is classified with parallel cousin or brother or sister. The Omaha kinship system differs from the Sudanese by classifying the cross cousin with certain other relatives. In the Omaha system Mo Br Da is terminologically classed with Mo Si and/or Fa Si Da with Si Da. When male relatives are classified in the Omaha system, Mo Br So is classed with Mo Br and Fa Si So is classed with Si So. The Crow system of classifying relatives is in essence the opposite or reciprocal of the Omaha system. In the Crow kinship system, cross cousins are called by different terms and neither are linked with parallel cousins or brothers and sisters. Fa Si Da is classed with and called by the same term as Fa Si and/or Mo Br Da with Br Da. Fa Si So is classified with Fa Br and/or Mo Br So with Br So.

Using only female terms each type of cousin terminology may be briefly outlined as follows:

Eskimo: Cross and parallel cousins classified together but they are differentiated from sisters.

Hawaiian: Cross and parallel cousins are classified together and they are classed with and called by the same term as sister.

Iroquois: Both cross cousins classed together but they are differentiated from parallel cousins and sisters.

Sudanese: Cross cousins are differentiated from each other and neither are classified with any other relative.

Omaha: Cross cousins are differentiated from each other and other relatives except Mo Br Da is classified with Mo Si and/or Fa Si Da with Si Da.

Crow: Cross cousins are differentiated from each other and from other relatives except Fa Si Da is classed with Fa Si and/or Mo Br Da is classed with Br Da.

The type of kinship terminology by which a society classifies its kindred is not arbitrary but is dependent upon or associated with specific types of social organization. In societies whose social organization is organized around bilateral principles, the type of cousin terminology usually associated with bilateralism is either Eskimo or Hawaiian. An Omaha kinship system is generally associated with patritineal organization while Crow terminology is the matrilineal equivalent. Sudanese cousin terminology is functionally in equilibrium with unilinear organization, but its limited and localized distribution results in its almost exclusive association with patrilineal societies. Iroquois terminology is found among societies which have either matrilineal or patrilineal organization. White (1939) has suggested that the Iroquois kinship system is generalized type and that Omaha and Crow are mature or more highly developed forms of Patri or Matri-organization. Murdock (1949) confirmed White's hypothesis by demonstrating the following:

1. Societies with Iroquois terminology had more traits which were not in harmony with matri—or patri—organization than did societies with Crow or Omaha organization.
2. Initial or early forms of matri—or patri—structure, such as

matri—or patri—clans or families, were more often found in societies with Iroquois terminology than with Omaha or Crow.

3. Mature or late developing structures such as moieties were more often present in societies with Crow or Omaha kinship terminology than with Iroquois.

Although Iroquois terminology can be considered as a transitional form, it is also a relatively stable form of organization. Murdock's sample of societies confirm the stability of Iroquois terminology. In his sample there are more patrilineal tribes with Iroquois terminology than with Omaha. In a similar manner there are more matrilineal tribes with Iroquois terminology than with Crow. Among most societies with Iroquois terminology the shift from Iroquois to Crow or Omaha requires considerable modification of the kinship system. However under certain circumstances the shift may be made quite easily. One means of making this shift is present if a society with an Iroquois type of terminology has the terms aligned in such a manner that Crow and Omaha linkages are present. The stable form and the transitional form of Iroquois terminology are present among two closely related north Wintun dialects.

The following Table I taken from Gifford (1922) indicates the terms used by the Northwestern, Northern and Northeastern Wintun dialects

TABLE I. Kinship terms utilized by the Northwestern, Northern and Northeastern Wintun which indicates Omaha and Crow Relationship.

Relative	*N. W.*	*N.*	*N. E.*	*Linkages*
Fa Si	Puta	Puta	Puta	Crow
Fa Ol Si Da	?	Puta	Nene	
Fa Yr Si Da	?	tcami	Nene	Omaha
Si Da	tcai	tcami	tcami	
Mo Si	Nene	Nene	Latcibet	Omaha
Mo Ol Br Da	Nene	Puta	Nene	
Mo Yr Br Da	Nene	tcami	Nene	Crow
Br Da	Bitcende	Pukwi	Pukwi	

for various relatives critical to the classification of cousin terminology type.

Table I indicates that the Northwestern Wintun have an Omaha linkage in that Mo Br Da is classified with Mo Si. Since Gifford did not list a term for Fa Si Da the type of cousin terminology possessed by the Northwestern Wintun cannot be determined with certainty from the data available.

The Northeastern Wintun has a typical or stable form of Iroquois terminology. Mo Br Da, termed "nene" is classified with Fa Si Da and neither are classified with any other critical classificatory relative. To make the shift to the Crow or Omaha system, the cross cousin must be differentiated and the proper link with another critical relative be established.

Among the Northern Wintun the cross cousins are classified together which makes the classification of the system Iroquois but two terms rather

than one are used. The Northern Wintun makes a distinction between the older and younger sibling of the parents. Thus "Puta" is the term used to indicate mother's older brother's daughter and father's older sister's daughter. While "tcami" is used to indicate father's younger sister's daughter and mother's younger brother's daughter, the use of these terms for cross cousins give the Northern Wintun both Crow and Omaha linkages. Fa Ol Si Da, "Puta," is classified with Fa Si which is a crow linkage and Fa Yr Si Da, "Tcami," is classified with Si Da which is an Omaha linkage. Since the linkages are already present, the Northern Wintun could shift to either Crow or Omaha terminology by a simple process of loss of terms. In this situation it would involve only the loss of the distinction between the relative ages of the parent's siblings. By retaining the terms used to designate Fa Ol Si Da and Mo Yr Br Da and by dropping the terms used to indicate Fa Yr Si Da and Mo Ol Br Da the Northern Wintun could shift out of Iroquois into the Crow system. In a similar fashion by retaining the terms for Fa Yr Si Da and Mo Ol Br Da and dropping the terms for Fa Ol Si Da and Mo Yr Br Da, the shift from Iroquois to Omaha terminology could be made.

To state that a transfer of cousin terminology system could be made need not necessarily imply that such a transfer will be made. Yet the presence of both Crow and Omaha lineages gives the Northern Wintun a system of cousin terminology which is functionally out of balance with other elements of social organization. There are no social forces present which would tend to cause the alignment of Mo Br Da with either Fa Si or Si Da. Among the Northern Wintun there would be pressure to dissociate these relatives either by equating Mo Br Da with Mo Si or Br Da. The tendency to link Mo Br Da with Mo Si would arise as a result of patrilineal ties or Mo Br Da with Br Da would develop from matrilineal association. If the forces present were bilateral instead of unilateral, there would be a tendency to drop Omaha and Crow alignments and to equate Fa Si with Mo Si and Si Da with Br Da.

Whether the forces operating upon the kinship system are bilateral or unilateral can not be determined. It seems clear that the forces present are causing a trend away from the Omaha type of organization. In the central California area Omaha cousin terminology is quite common but many societies appear to have moved out of it. Among the six Pomo dialects, four have Omaha organization but evidence suggests that the Southwestern Pomo has shifted from Omaha to Hawaiian terminology and the Southern Pomo has made the shift from Omaha to Crow. The Wappo which has Crow organization has several Omaha survivals in their kinship system indicative of former Omaha organization. Among six of the Yokuts' dialects, three have Omaha organization and three have Hawaiian. Evidence suggests that the Hawaiian type developed from former Omaha structure. It is also clear that the Iroquois terminology of the Northern and Northeastern Wintun is derived from former Omaha organization.

The Northern and Northeastern Wintun are closely related dialects. Their dialect relationship to the Northwestern Wintun is more distant. Yet the Northern and Northwestern Wintun have terms in common for Mo Si "nene" while the Northeastern Wintun has a unique term "Latci-

bet." Also the Northeastern and Northwestern Wintun utilize the same terms for Mo Br Da "nene" while the Northern Wintun utilize two terms "Puta" and "tcami." The two different types of Iroquois terminology indicate that the Iroquois terminology is of recent origin and did not develop until after the two closely related dialects had diverged. It is also apparent that the former system was Omaha. The Northwestern Wintun are still Omaha since they classify Mo Br Da with Mo Si by utilizing the common terms "nene." Since "nene" is Mo Si in Northern Wintun and Mo Br Da in Northeastern Wintun it indicates that these are old terms for these relatives and that each would have formerly been Omaha. "Latcibet" which is Mo Si among the Northeastern Wintun and "Puta" and "Tcami" which is Mo Ol Br Da and Mo Yr Br Da respectively are recent innovations which developed as a result of the movement out of Omaha organization.

Although the Northern Wintun could move toward a bilateral type of organization instead of toward Crow organization, the Northern Wintun form of Iroquois terminology at least indicates a means whereby the transition from Omaha to Crow structure or vice versa could take place easily and rapidly. With the Northern Wintun form of terminology, a society could change from one system to another with only loss or substitution of terms which would not involve the more difficult process of invention. Since a rapid change is possible, one might question the validity of White's hypothesis that Crow or Omaha represents exclusively the mature forms of matri- or patri-organization. How valid this criticism may be cannot at present be determined because the frequency of a rapid change from Omaha to Crow or vice versa is not known.

The Northern Wintun form of Iroquois terminology also casts doubt upon one of Murdock's hypotheses. Murdock has postulated that the change from matri to patri-organization can occur very rapidly but that the change from patri to matri is an exceedingly difficult process. The Northern Wintur form of terminology would make one shift as easy as the other. One central California group, the Southern Pomo, seems to have made the shift from Omaha to Crow in an exceedingly short period of time.

In summary we can state that the Iroquois type of terminology is one of six possible types and that each type results from forces which are present in a society's social organization. Normally, Iroquois terminology is relatively stable and the transition to Crow or Omaha terminology involves a considerable amount of modification of the kinship system. The Northern Wintun form or variant of Iroquois terminology represents one means whereby the transition to Crow or Omaha can be made easily. Thus normal Iroquois terminology functions as a stable system while the Northern Wintun form functions as a transitional type.

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A Possible Early Woodland Cache Discovery in Northern Indiana

Charles H. Faulkner, Culver, Indiana

In the spring of 1947, Russell A. Quillen of Plymouth, Indiana, an ardent collector of Indian artifacts, noticed that several blades of a distinctive type had been exposed in a relatively small area on a sand ridge in Green Township, Marshall County, Indiana. Obtaining permission from the owner to excavate on the ridge, Mr. Quillen and his son troweled and brushed away the sand in the area where the blades were being unearthed by wind and cultivation. In an area not more than five feet wide and ten or twelve feet long, over 300 whole and broken ovate-trianguloid cache blades were discovered. The ridge had been cultivated in an east-west direction, and the scattering of the blades in this direction provides ample evidence that the upper layers of the cache had been disturbed by the plow, probably for many years. Repeated cultivation of the site can also be held accountable for the many broken blades included in the discovery. In one area Mr. Quillen stated that, "not more than 18 inches in diameter, the points lay in a circle pointing in and for several layers." The cache blades were found to a depth of 18 inches below the surface, and below this point nothing was found. No associated artifacts or skeletal material was noted with the cache blades, nor was the soil around them discolored by artificial means (i.e. red ocher). Photographs and color movies were taken during the excavation, but nothing significant is revealed in either medium.

In the summer of 1959, the writer became acquainted with Mr. Quillen during an archaeological survey of Marshall County. Mr. Quillen proved to be most co-operative and allowed the writer to examine and photograph the cache blades in his possession. An immediate visit to the site by the author disclosed the following aspects of the natural setting.

The locus of the cache discovery is a sand knoll which is a part of an undulating sand ridge that traverses the countryside in a general east-west direction. This fine "ginger sand", of dune origin, was carried here by westerly Pleistocene winds from the shores of former glacial Lake Chicago. These sandy ridges were favorite camping sites for the earliest inhabitants (Paleo-Indian) of Marshall County, as well as the historic Miami and Potawatomi. The underbrush was probably not rank on this acid sand, and oak trees undoubtedly dominated the larger flora on the site. Several hundred yards south and below the ridge is Eddy Lake, a small pond with an outlet creek meandering to the east. Here was an ideal location for a camp or village; water was nearby and the small pond probably teemed with waterfowl and fish. The unbroken forest was the larder for game of all kinds. The unbroken forest is gone; the ridge is now cultivated and planted in corn. Wind erosion has blown away the sand between the corn rows leaving behind the lithic evidence of aboriginal occupation.

The cultivated portion of the ridge boasts of two knolls on which occurs evidence of habitation. The "saddle" between these two natural mounds displays a gravelly subsoil and no evidence of occupation. A country road cuts through the ridge just east of the knoll on which the cache

was found. On the east side of this road is a knoll which appears to be the highest point on the ridge, but this area was in pasture, thus making a surface survey impossible.

The surface survey on the cultivated portion revealed fire-cracked rock and chips and spalls of flint and chert in profusion. Few artifacts were found on these habitation areas which have been designated 12Mr^{v}-215, the county site number. Several projectile points of a generalized Woodland type were found, plus scrapers and other crude tools. The only possible diagnostic evidence discovered on the cache knoll were two fragments of grit-tempered, cord-marked pottery. Although minute, the fragments appear to represent a thin-walled vessel of a later time period; however, considering the size of the site (several acres), the portion surveyed appears primarily non-ceramic. In any case, it is probably safe to assume that this site was utilized as a camping ground for several thousand years. Sometime during the earlier periods of the sites' occupancy, the cache blades were buried here, as we shall presently see.

Mr. Quillen claims 463 whole and broken specimens were found on the site during the spring of 1947. This number includes a few blades that were picked up on subsequent visits to the site. His son received at least 50 whole blades according to Mr. Quillen; and the writer has examined the specimens remaining in Mr. Quillen's possession. This sample of the cache contains 114 whole blades plus 58 partially broken ones. Badly damaged specimens include 77 bases and 43 points. Twenty blade fragments round out the number of artifacts available for study. One disc-like scraper of the same lithic material as the blades; a side scraper of a different chert medium; and a small, broken notched projectile point were found included with the blades. These artifacts are probably strays from the habitation debris which abounded in the sand around the cache deposit.

The blades are all fabricated from a material that strikingly varies in color and texture, but undoubtedly stems from a common source. The medium of construction is basically a fossiliferous chert which ranges from a dark, highly compact variety through lighter greys and tans, to a very friable brown material. These blades exhibit various combinations of these varieties, revealing either a glacial chert nodule or a bedrock chert vein or nodule was utilized. Seymour Greenberg, industrial geologist at Indiana University, examined some of the artifacts and stated that the white to grey colored blades contain a chert that is compact, and the brownish, sandy-textured artifacts contain chert that is loose and friable. Small amounts of quartz and feldspar are present in the brownish-colored specimens. The white and grey chert probably came from a carbonate rock such as limestone or dolomite, but since these rocks are not exposed in the Marshall County area because of a great depth of the glacial drift, Mr. Greenberg believes the source was a nodule in the drift itself. The brownish, friable chert may represent glacial dust that was carried down by the glacier and later compacted to some degree in association with the denser chert. The fact that some flint and chert utilized in the northern Indiana area appears to have its origins in the Illinois River Valley indicates the prehistoric artisans traveled far to obtain their raw materials. In sum, the raw material for this cache probably came from the Illinois River Valley, and was obtained from either glacial or bedrock deposits.

This source becomes plausible when the origin of the cultural bearers of these artifacts is discussed later in the paper.

Because no diagnostic material was found with this cache, the overall size and shape of the blades must be used for a comparison to similar caches found in the eastern United States. In length, the blades are distributed from 44mm to 78mm, with approximately 66% of the artifacts falling between the lengths of 55mm to 63mm. The most common length was 59mm. The range of width sizes varies from 22mm to 36mm; 28mm proved to be the prevailing width. Thickness of the blades ranged from 5mm to 12mm and the most frequent measurement recorded was 7mm. In overall shape the blades exhibit a slight variance, but this is not of typological significance since the artifacts were not measured with a micrometer or machine produced by the Indian artisan. This variance in shape can be noted in Figure 1. The writer refers to the general shape

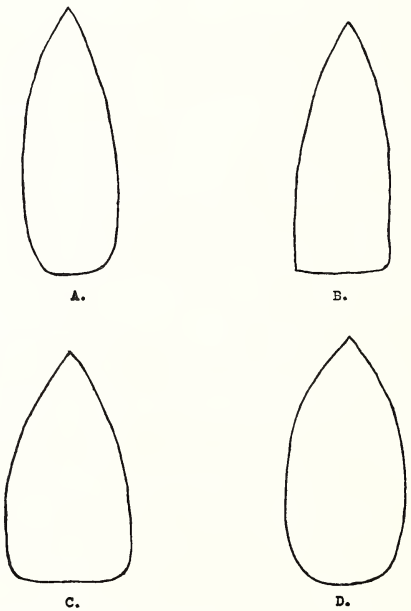

FIGURE 1. Outlines demonstrating the variance in shape of the Marshall County cache blades. A. Elongate blade, base slightly rounded B. Elongate blade, straight base (pentagonal) C. Wide blade, straight base (pentagonal) D. Wide blade, base rounded.

as ovate-trianguloid. The term pentagonal could be used in some instances, but on many of the specimens the edges near the base are incurvate. A true trianguloid shape cannot be applied, for although many of the bases are straight, others are slightly convex. The term "leaf-shaped" is avoided here, as it should have been in the past. Unfortunately, the contents of many caches have been described in this vague manner.

Intergrades of workmanship occur in the sample, and the following observational conclusion may be drawn without hesitancy. These blades are

not finished tools or weapons. Some specimens have slight secondary flaking along the edges, and nicks along the edges from the initial flaking process have been retouched to preserve the symmetry of the finished product; however, the widespread feeling now prevails that caches such as this represent a storehouse of needed material for finished tools and weapons.

Although the variety of sizes and shapes has no real significance within the Marshall County series itself, a previous statement revealed that a comparison to similar cache blades of other cultural groups could demonstrate cultural parallels. At first glance, the similarity of the Marshall County blades to those found with an early Point Peninsula burial complex was striking (Ritchie, 1955). At the Red Lake Site, 243 thin, trianguloid cache blades were found in association with a bundle burial and cremated remains (Ritchie, 1955). According to Dr. William A. Ritchie the Red Lake interments represent the endeavors of an Early Woodland (Carbon 14 date—2500 B. C. ± 260 years) burial cult in the Northeast (Ritchie, 1955). Because the most common length and width figures for the Marshall County blades were so similar to those of the Red Lake Site, two typical blades were sent to Dr. Ritchie for examination. Dr. Ritchie stated by correspondence: "Although the overall shape and size of the blades could be matched within the Red Lake series, these (Marshall County specimens) are much too thick to be considered similar to early Point Peninsula mortuary blades." Concerning possible cultural affiliations for the Marshall County specimens, Dr. Ritchie commented thusly: "I have seen blades of approximately this size, shape, and thickness from New York Middlesex sites, but I suggest that the closest similarity to your blades may be found in the Red Ocher Focus."

The Middlesex Focus of the northeastern United States shows definite relationships to the Adena Phase in the Ohio area which in turn shares many traits with the Red Ocher Focus of Illinois (Ritchie, 1944). To the authors' knowledge, no definite Adena or Red Ocher sites have been reported in northern Indiana, but the probable Early Woodland Glacial Kame Focus is well represented by burials found in our northeastern counties (Cunningham, 1948). Ritchie places the Glacial Kame Focus into the same horizon as Middlesex and Red Ocher (Ritchie, 1944 and 1955), and Martin, Quimby, and Collier feel that this culture was contemporaneous with late Adena (Martin, Quimby, and Collier, 1947). A Glacial Kame origin for the Indiana cache blades appears most logical because of adequate representation in the area, but cache blades are not a mortuary trait in Glacial Kame as they are in the other Early Woodland manifestations under discussion (Cunningham, 1948). This focus is still poorly defined, but the frequent occurrence of this trait in other related groups seems to rule out Glacial Kame manufacture.

Caches of "leaf-shaped or lanceolate blades" have been found with cremations, flexed inhumations, and possible bundle burials in Red Ocher mounds in Fulton County, Illinois (Cole and Deuel, 1937). Recent excavations at the Morse Site, Fulton County, Illinois, have produced 60+ blades of the ovate-trianguloid type in association with a flexed Red Ocher burial (Morse, 1959). Although no actual comparisons have been made between the Marshall County specimens and the Morse blades, a photograph of the latter reveals the size, shape, and color varies as do

the Indiana specimens, although the ovate type dominates in shape (Morse, 1959). Some of these Red Ocher blades have a tendency to be more incurvate toward the base, thus differing from our Indiana blades in being more Adena-like in form.

Adena cache blades appear to be more ovate than the Marshall County blades; excurvate bases in lieu of straight ones, and blunter ends tend to differentiate these blades from the Indiana specimens. This comparison was made from a photograph of the 75 ovate blades from the Fisher Site, an Adena mound in Fayette County, Kentucky (Webb and Haag, 1947b). In *The Adena People*, Webb and Snow discuss the Adena cache blades as follows:

> "This has occurred with sufficient frequency to indicate some special reason for it. It may be that in some instances when these caches accompanied the dead, these flint knives were regarded as somewhat unfinished, possibly to be completed in the world of spirits, and therefore, represented potential value, since being unspecialized they still could be made into knives, scrapers, projectile points, drills, reamers, or gravers, at pleasure." (Webb and Snow, 1945)

Conclusions

A lack of apparent details and associations plus the disturbed nature of the Marshall County cache deposit make a precise correlation with an Early Woodland group almost impossible; however, a probable choice would be the Red Ocher Focus. Although cache blades of the Illinois focus are found as part of a mortuary assemblage, an absence of skeletal material with the Marshall County cache could be explained as follows. The sand ridges of northern Indiana are subject to intense wind erosion. Some of the blades were found on the surface, indicating an unknown amount of top soil and sand have been blown away since the ridge was initially cleared. When the continual cultivation of the ridge is also taken into consideration, a cremation, or even a flesh burial could have been scattered and destroyed. Other poorly documented cache deposits with no mention of burial association have been found in the Great Lakes region, notably in Saginaw County, Michigan (Dustin, 1941). There is every possibility that the isolated Marshall County cache represents a hidden store of unfinished "blanks," to be later used on the habitation site to make tools and weapons as needed. The continued quotation from *The Adena People* reveals:

> "While such caches are found as burial offerings, they are also found apart from burial association. Caches have been found in villages and in mounds out of association with burials, and in mounds, and under rock shelters in burial association." (Webb and Snow, 1945)

Because the Red Ocher Focus appears to be very similar to Early Adena (Webb and Snow, 1945), isolated storage caches of ovate-trianguloid blades may be an undiscovered trait on Red Ocher habitation sites.

A movement of an Early Woodland, Red Ocher people up the Illinois and Kankakee Rivers into northern Indiana is the best argument for the presence of these blades in Marshall County. The Middle Woodland Goodall Focus found along the Kankakee and its drainage (Yellow River in Marshall County) has its origins in the Illinois River Valley (Quimby,

1941b). There is no reason to doubt a preceding Early Woodland migration up these streams into northern Indiana.

The Red Ocher people made a thick, grit-tempered, cord-marked pottery (Cole and Deuel, 1937), and the writers' discovery of a similar type of pottery in Marshall County could be interpreted as additional evidence for their presence. The Early Woodland cultural pattern in northern Indiana does not appear homogeneous, however. Surface finds of cigar-shaped. stone tubular pipes and bar-type birdstones attest to the presence of the Glacial Kame Focus, the burial complex now generally regarded as Early Woodland (Ritchie, 1949b). Glacial Kame in this area could have its origins to the north and east, and the physical type differs markedly from that of the Red Ocher Focus. The Red Ocher people were a very dolichocephalic type of the Paleo-Amerind or Otamid variety (Personal communication with Georg Neumann, 1959), whereas the Glacial Kame is a dolichocephalic Lenapid entity (Neumann, 1949). The question of which came first is like that concerning the chicken and the egg. The similarities of the burial ceremonialism of certain eastern Glacial Kame sites to the Red and Muskalonge Lake burials and cremations could indicate a greater antiquity for Glacial Kame because of the Carbon 14 date of 2500 B. C. ± 260 years for the Red Lake Site (Ritchie, 1955). An absence of pottery also indicates a great age for this focus, although the eventual excavation of a Glacial Kame habitation site may reveal Early Woodland ceramics. On the other hand, Neumann maintains a greater age for the Red Ocher Focus because the Otamid physical type appeared early in North America, and was later pushed into marginal areas (Personal communication with Georg Neumann, 1959). A Carbon 14 date for a Red Ocher site would help solve this problem. The Morse Site has not been Carbon 14 dated, but Griffin postulates a date around 1500 B. C. (Personal correspondence with James B. Griffin, 1959).

The author feels that Red Ocher and Glacial Kame were contemporaneous in northern Indiana for at least part of their existence, and the Early Woodland horizon in northern Indiana represents an overlap of both cultural traits and physical type of the two entities. If future Carbon 14 dates for both foci do not demonstrate a great discrepancy, and future excavation reveals an early ceramic art on Glacial Kame habitation sites, this conjecture will be validated. This amalgamation would boast of early Point Peninsula-like cultural traits which through modifications and new additions would provide the basis for the later Woodland cultures in the Great Lakes region.

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BACTERIOLOGY

Chairman: WALTER A. ZYGMUNT, Meade-Johnson Research Laboratory
WALTER A. ZYGMUNT was re-elected chairman for 1960

ABSTRACTS

PPLO in Tissue Cultures. DOROTHY POWELSON, Purdue University, Lafayette.—Pleuropneumonia-like organisms were inoculated into cultures of animal tissue cells to determine their effects on the morphology and metabolic behavior of the cells. The PPLO produced no effect on the morphology of the cultures when they were young. As the cultures became more densely populated some cells became more granular, and finally large numbers became detached from the glass. Surviving cells gave rise to new monolayers. In inoculated cultures of strain L mouse fibroblasts, fed first with a synthetic medium (Morgan's 416) plus 5% horse serum and later with the synthetic medium alone, several cycles like this occurred during the five-month period that these cultures were maintained.

In short-term experiments no cytopathologic effect was evident. Nevertheless, cultures of explants of chick embryo heart and strain L, inoculated with PPLO, showed a change in the pattern of uptake of amino acids from the medium. Arginine and glutamine were the amino compounds chiefly involved. PPLO, 30-fold concentrated from broth cultures and suspended in M416, took up arginine and glutamine. Whether such concentrations of PPLO were present in the cells of the cultures was not determined. The supernatant fluids contained only moderate numbers of PPLO.

This work was undertaken to find out what interference PPLO might introduce in experiments with tissue culture systems. It is apparent that results of investigations on the nutrition and metabolism of cell strains could be influenced by PPLO infection of test cultures.

Preliminary Report on the Flotation Method in Combination with the Fluorescent Antibody Technique Applied to Water Analysis. SAMUEL H. HOPPER, Indiana University Medical Center, and WALTER A. MILLER, Indiana State Board of Health.—Flotation is a method used in the mining industry to concentrate particles of minerals from an aqueous slurry. It consists of the addition of a chemical which will produce a hydrocarbon-like surface on the given particles. They then become hydrophobic and may be removed from the water by bubble attachment and aeration. On application of this method to turbid water, the mud and bacteria were concentrated in the foam. A method was needed for the quick identification of these microorganisms, and this was made possible by the development of the fluorescent antibody technique. Labeled antibodies were prepared using the fluorescent isothiocyanate method. Bacteria concentrated in the foam were readily identifiable by means of the labeled antibody. Specific formulae and details will be described. Preliminary tests indicate that this method may have some usefulness in water analysis.

The Chemical Composition of Walls of Myxobacterial Microcysts. JIMMY C. ADYE, Purdue University.—Microcysts of *Myxococcus xanthus* were prepared by a special method, to be described. The walls were removed by shaking the microcysts with glass beads in the Nossal shaker. They were purified by treatment with sodium chloride, to remove adsorbed nucleic acids, and differential centrifugation. The walls appeared to be free of cytoplasmic contamination when examined in the electron microscope. The walls constituted approximately 16% of the whole microcyst. The gross composition of the walls was 6% nitrogen, 12% carbohydrate, and 29% lipid. Paper chromatography was used to analyze acid hydrolysates for amino acids and carbohydrates. The amino acids found were those already identified in walls of other gram-negative bacteria; all of the amino acids identified in walls of vegetative cells of *Myxococcus xanthus* were present in the microcyst walls. Easily detectable were glucose, glucosamine, and galactosamine. Hexosamines, determined by the method of Blix, made up about 20% of the wall of the microcyst. Among other sugars present in small amounts rhamnose and arabinose were identified. The microcyst walls contained three carotinoid pigments that seemed to be the same ones found in the vegetative cell walls. The wall of the microcyst appears to make up a larger part of the cell than does the wall of the vegetative cell. Further, it contains more carbohydrate and less lipid. The nitrogen content and composition is approximately the same in walls of both kinds of cells.

A Semiquantitative Method for the Determination of Glucose in Cell Cultures. R. M. VAN FRANK, Eli Lilly and Company.—Glucose is reported to be the controlling factor in mammalian cell multiplication. Work with cell culture systems has indicated that it would be advantageous to have a simple means of measuring glucose concentration. After a survey of conventional methods indicated that each had certain disadvantages, TES-TAPE® (Urine Sugar Analysis Paper, Lilly) was tried. TES-TAPE® has proven to be a convenient means of estimating the glucose concentration in cell cultures.

Staphylococcus Phage Typing in a Regional Laboratory. MICHAEL C. CORAGGIO and WALTER A. MILLER, Indiana State Board of Health.—The Indiana State Board of Health laboratories have been designated as one of the twenty-four regional Staphylococcus bacteriophage typing centers by the United States Public Health Service. The value of bacteriophage typing lies in its ability to demonstrate the identity or non-identity of sets of related cultures. The significance of results is enhanced by the relative stability of the phages used and the lytic patterns of the cultures tested. A brief history of the evolution of the present system of *Staphylococcus* bacteriophage typing is given. An analysis of the laboratory data for the past year reveals that 55% of the *S. aureus* cultures submitted to this laboratory were typable with the 25 bacteriophages now in use. In addition, 78% of the typable cultures were found to be lysed by bacteriophages within the three broad groups recognized in the field.

Identity of the Protoplast Infecting and Cell Infecting Agent Derived from T_2 Bacteriophage[1]

Dean Fraser, Charles J. Pfau and Norman Pace, Indiana University

INTRODUCTION

Urea treatment of bacteriophage T_2 yields a new agent (pi) capable of infecting protoplasts of *E. coli*. Recently it was found that the pi also showed a small "background" count when plated with normal cells. Three possibilities were recognized as the possible source. First, some phage had been left intact by the urea treatment. Second, an unrecognized minority type of pi had been left able to attach to cell receptor sites. Third, a bacterial cell existed with some sort of defect in the cell wall and hence susceptible to pi. A combination of these three seemed also possible. If the source of background turned out to be a cell infectable by both phage and pi, it would be very valuable for genetic recombination between the two. This investigation was undertaken in an attempt to find the nature of the infective agent involved in this background count.

Phage and pi have very marked differences of inactivation rates by heat and proteolytic enzymes. Assays of inactivated pi on protoplasts and background cells should show different inactivation rates if the two are different agents.

METHODS AND MATERIALS

In all experiments, the host cell was *E. coli*, strain B, and the bacteriophage was T_2. Cells were grown in 3XD medium (1) with aeration at 37°C. The protoplasting procedure was as described previously (2). All pi (3) dilutions were made in D medium (2), and all protoplast dilutions in broth—bovine serum albumin (2). All heat inactivations were done in a thermostatically controlled, stirred water bath by procedures previously described (4). The proteolytic enzyme was the crystalline product from Worthington Laboratories and the procedure the same used previously (4).

Preparation of pi

T_2 was mixed 1/20 with 8M. urea (pH8.3-8.5). The resulting mixture was placed in a water bath at 37° for one hour. The pi was then dialysed overnight at 3°C against 0.15M saline to remove the urea and was stored under refrigeration.

Plating

In working with background, it is most important to use cultures of *E. coli* at a constant "age" because the background register otherwise varies markedly (5). For plating it is necessary to grow cells from a low inoculum to 5 x 10^6 cells/ml. (determined by Petroff-Hauser Counter). These cells yield a negligible background.

To obtain maximum background with pi, cells grown to 5 x 10^8/ml. are

1. Assisted in part by a grant from the National Cancer Institute of the U. S. Public Health Service (C-2772).

placed under refrigeration for at least two weeks. This brings the background titer to around 10^3 counts/ml. In this investigation, cells which had been refrigerated for three weeks were used.

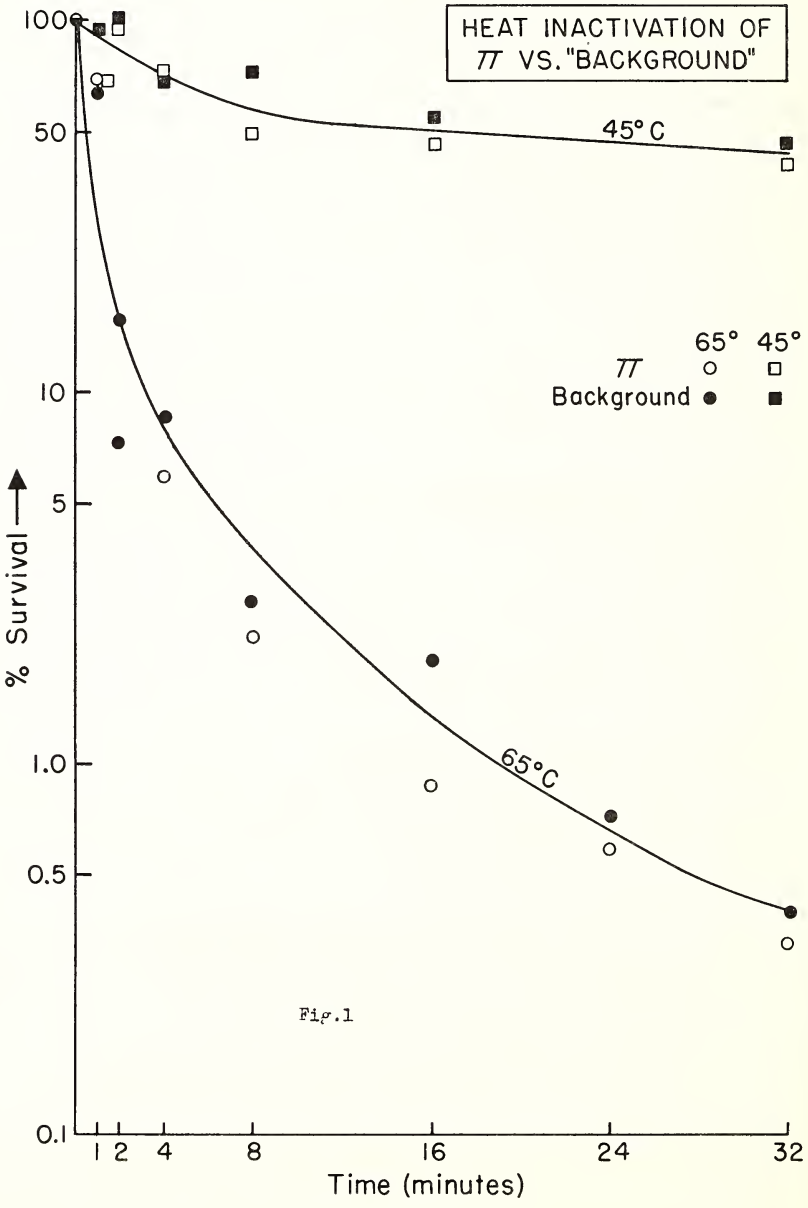

Fig. 1

Figure 1

RESULTS

Heat inactivation of pi

Both cell and protoplast assays of pi inactivated at 65°C are shown in Fig. 1. As may be seen, the assays conform reasonably. In order to eliminate freak correspondence of inactivation rates at 65°C, the pi was inactivated at 45°C. Again, the experiment (Fig. 1) showed no difference in inactivation rates.

Trypsin inactivation of pi

Pi and phage also exhibit different inactivation rates when treated by the proteolytic enzyme trypsin (phage being completely stable to the enzyme). The trypsin-inactivated pi was assayed with cells and protoplasts. Again the rates of decline of activity against protoplasts and cells were parallel.

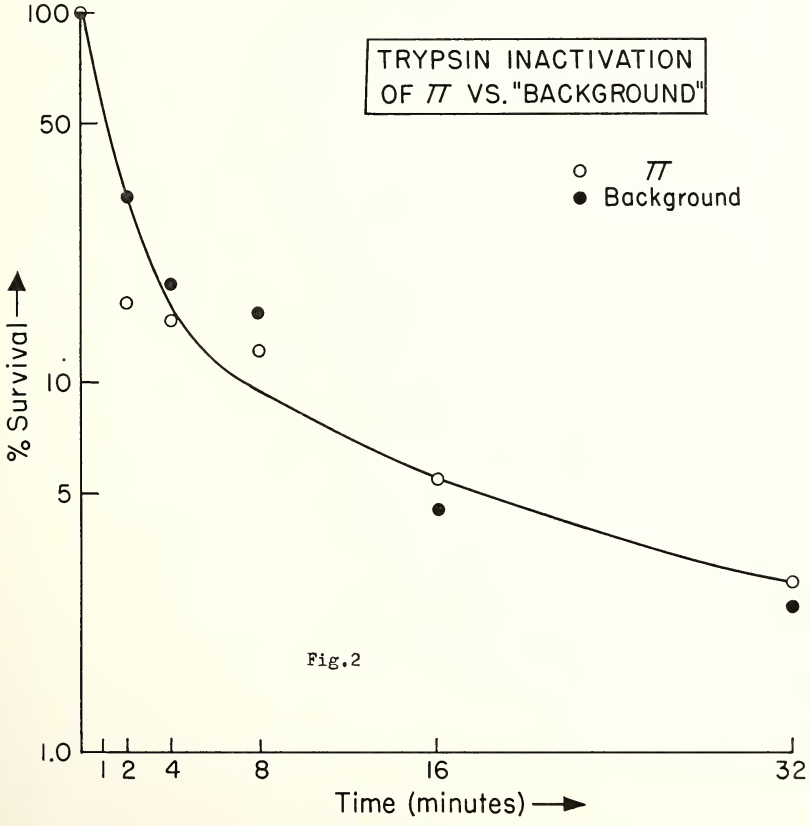

Fig. 2

Figure 2

DISCUSSION AND SUMMARY

The above evidence tends to indicate that pi itself is the infective agent causing background count. The possibility of existence of a bac-

terium with some sort of incomplete cell wall is under investigation. Preliminary evidence points to an "unusual" cell as responsible for backgrounds (5).

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BOTANY

Chairman: CHARLES HEISER, Indiana University
S. N. POSTLETHWAIT, Purdue University, was elected chairman for 1960

ABSTRACTS

The Cytotaxonomy of *Helianthus petiolaris*. CHARLES B. HEISER, JR., Indiana University.—The wide ranging annual sunflower, *Helianthus petiolaris* Nutt, is quite variable and two major morphological races may be recognized: subsp. *petiolaris*, primarily a plant of the Great Plains and a weed in the central and eastern United States, and subsp. *fallax* of the southwestern United States. Over forty samples of *Helianthus petiolaris* have been employed in a hybridization program, and a study of F_1 hybrids reveals that three cytogenetic groups are present: *A*. Minnesota *(H. petiolaris* subsp. *petiolaris); B*. Indiana, Missouri, Illinois, Kansas, northern Oklahoma and California *(H. petiolaris* subsp. *petiolaris); C*. South Carolina, southern Oklahoma, Texas *(H. petiolaris* subsp. *petiolaris);* Utah, New Mexico, and Arizona *(H. petiolaris* subsp. *fallax).* Crosses of different samples within any of the three cytogenetic groups produce fertile hybrids, whereas hybrids between samples from different groups give hybrids with reduced fertility. Examination of meiosis in hybrids of the latter category indicates that the parental types differ by one or two translocations. Group *A* differs from *B* by one translocation and from *C* by two translocations. Group *B* also differs from *C* by two translocations. It is of interest to note that Group *C* is composed of both subspecies, indicating that morphological differentiation has not paralleled the cytological differentiation.

A Preliminary Investigation of the Influence of the Leaves and Axillary Buds upon Apical Elongation in *Tilia americana* L. A. T. GUARD and S. N. POSTLETHWAIT, Purdue University.—Instead of forming an essentially straight axis in early development the young internodes of *Tilia americana* L. are often oriented in such a manner that the lines formed by two adjacent internodes make an angle in excess of 45°. By means of dissecting away young leaves and buds and comparing the development of these twigs with untreated controls an attempt was made to determine the effect of these organs on the elongating stem. Our experiments indicate that the developing leaves influence the angle of stem development markedly. The influence of axillary buds appears to be insignificant. Presence of leaves also appeared to result in marked increase of internode elongation. Sections of the stem tip show that this angular type of growth is initiated very early in the ontogeny of the stem.

A Square-stemmed Corn Plant. S. N. POSTLETHWAIT and O. E. NELSON, Purdue University.—The orderly progression of events culminating in which is considered a "normal" plant occasionally is interrupted or diverted by mutant genes, environmental disturbances, or some clandestine cause. The morphological expression of this alteration often

provides considerable information on how the "normal" form comes into being. A corn plant discovered in the genetic plots at Purdue University shows considerable promise as a possible tool for this kind of study. The plant has a decussate arrangement of leaves and a square stem. Ear shoots were formed in the expected axillary positions. Two ear shoots occurred on opposite sides of the stem at each of three nodes. No fertile grains were produced, however adequate pollen was obtained for outcrossing. Since the decussate arrangement of leaves and a square stem are the only digressions superimposed on the "normal" morphological pattern, one can anticipate that a future study may be very helpful in the age-old problem of meristem variation and phyllotaxy.

Development of Flavonoid Pigmentation in Buds of *Impatiens balsamina* L. CHARLES W. HAGEN, JR., Indiana University.—Mature petals of *Impatiens balsamina* of the genotype $11HHP^{r}P^{r}$ contain a 3,5-diglucoside and an acylated 3,5-diglucoside of pelargonidin as well as free kaempferol, a kaempferol glucoside and another flavonol glycoside which is probably a second glucoside of kaempferol. Sepals of the same plants contain the same pigments, but in addition have derivatives of cyanidin, peonidin, and quercetin. Petals which develop pigmentation in culture produce the pigmentation characteristic of sepals. (A. Klein, thesis, 1959.) In petals of developing buds, leucoanthocyanins appear first, flavonols follow and the anthocyanin glucosides appear last in a sequence which indicates that sugars and other substituents are added in stepwise fashion to a preformed aglycone. This developmental study also has implications which affect conclusions to be drawn from evidences of competition between flavonoid pigments.

Development of *Polyphagus* in Algal Culture. ROBERT M. JOHNS, Indiana University.—Several isolates of the parasitic chytrid genus, *Polyphagus*, have been isolated and grown in culture on algae from the Indiana University Algal Culture Collection. A continuing study of the host range and specificity of the parasite has more than tripled the number of algal genera that the fungus is known to attack. Isolates exhibit considerable morphological variation depending on the conditions of culture and the host organism on which they are grown.

Preliminary Studies on the Migration of the Root-knot Nematode, *Meloidogyne incognita acrita*. G. B. BERGESON, Purdue University.—Field studies of root-knot nematode populations have indicated that during the non-growing season, or when a field is in fallow, a high percentage of the total root-knot nematode population is present in the 2nd and 3rd foot soil depths. Greenhouse studies initiated to determine the vertical migration from these depths indicated that within a 1-6 week period a maximum upward migration of 21-24 inches had taken place. Migration occurred only in the presence of plants. Where no plants were grown the nematodes did not move out of their original placement site. The application of root exudates to root-knot infected soil columns were successful in inducing upward migration, thus confirming the stimulatory effect of root exudates on migration.

Factors influencing the Fungitoxicity of Phenolic Compounds. JOSEPH KUC and TOMIE MAXAM, Purdue University.—Chlorogenic and caffeic acids are phenolic compounds often implicated with disease resistance mechanisms in plants. These compounds differ in their effect on the growth of *Helminthosporium carbonum* Race 1, an incitant of a leaf spot in corn, depending on the composition and pH of the nutrient medium employed in the assay. Chlorogenic and caffeic acids $1X10^{-2}M$ each inhibit the growth of *H. carbonum* in potato-dextrose broth at a pH range of 4-8. In Czapek's medium, however, chlorogenic acid markedly stimulates growth of the fungus within the same pH range; whereas, caffeic acid totally inhibits growth at pH 4, 5 and 8 and stimulates growth at pH 6 and 7. The addition of quinic acid, a component of the chlorogenic acid molecule, to Czapek's medium containing caffeic acid at a pH of 4, 5 or 8 does not reverse the inhibition. Czapek's medium, however, containing L-alanine or L-phenylalanine $1X10^{-2}M$ and caffeic acid $1Z10^{-2}M$ at a pH of 6 or 7 completely inhibits the growth of *H. carbonum.* The formation of toxic phenol and quinone amino acid addition products in potato-dextrose broth and in Czapek's medium containing L-alanine or L-phenylalanine may explain the observed growth differences. The composition and pH of the nutrient medium may also affect the production of extracellular phenoloxidases by *H. carbonum* and other fungi, thereby controlling the oxidation of phenols in the nutrient medium.

The Relation of Certain Fungi to Root and Collar Rot of Apple. ZOFIA MACIEJOWSKA and E. B. WILLIAMS, Purdue University.—Roots of diseased apple seedlings and trees were examined and isolations of microflora associated with the diseased tissue were made. Species of eleven genera, *Fusarium, Rhizoctonia, Botrytis, Mucor, Alternaria, Trichoderma, Verticillium, Pythium, Penecillium, Phytophthora,* and *Gliocladium,* were found to be commonly associated with diseased roots. Species of five of these genera, *Fusarium, Phytophthora, Pythium, Alternaria* and *Rhizoctonia* were found to be pathogenic on apple seedling roots. Non-sterilized rain water was used to facilitate the isolation and identification of *Phytophthora.* In this medium sporangia developed after three days. The *Phytophthora* species produced profuse mycelial growth on corn-meal agar but this medium was not favorable for the production of sporangia and oospores. *Rhizoctonia solani* was found to be the most serious cause of damping off of young apple seedlings. This organism spreads very quickly through the seed flat and causes complete loss of seedlings. *R. solani* is a rare contaminant on apple seed; while *Fusarium sp.* and *Alternaria sp.* commonly occur on the seed coat. Inoculations were made on apple seedlings with *Phytophthora* isolates from trunk cankers on apple trees. No infection was observed after thirty days.

Studies on Teliospore Formation and Germination in *Puccinia coronata.* D. E. ZIMMER, JOHN F. SCHAFER, and GEORGE A. GRIES, Purdue University.—The occurrence and rate of telial formation of *Puccinia coronata* var. *avenae* was studied in 8 mono-urediospore cultures representing 6 races. The rapidity of telial development was not correlated with virulence of the pathogen or degree of host resistance. No relationship existed between range of virulence of the rust culture and rate of telial produc-

tion. Neither was developmental stage of the host a limiting factor in telial formation. Telia formed as readily on seedlings as on mature plants. It was concluded that the rapidity of telial production is the result of a specific relationship between the host variety and the particular rust clone concerned. Rate of telial development was directly affected by temperature. No experimental methods were found to induce telial formation in non-telial producing cultures. Germination of greenhouse produced teliospores of *P. coronata* var. *avenae* was attempted. These teliospores were not induced to germinate by alternate wetting and drying, alternate freezing and thawing, leaching with water, mechanical separation, or combinations of these. Overwintering outdoors of greenhouse produced teliospores also failed to induce germination. Teliospores collected from the field and subjected to various chemical treatments were not stimulated to germinate, although natural overwintering of these resulted in abundant germination.

A Virus from White Clover in Indiana. J. B. BANCROFT, J. F. TUITE and G. HISSONG, Purdue University.—A mechanically-transmissible virus has been isolated from white clover in Indiana. The virus is serologically related to viruses recently found in Holland and California. The host range of the virus includes 26 species in the following families: *Convolvulaceae, Cucurbitaceae, Leguminosae, Solanaceae, Tropaeolaceae.* The physical properties of the virus are: dilution end-point, about 1:100,000; thermal inactivation, between 65° and 75°c; longevity *in vitro*, < 2 weeks. The virus remains soluble and infective at pH 5.0 and is a nucleoprotein. The virus is a moderately flexuous rod. The average particle length of the modal distribution is 477 mμ and the width is about 15 mμ.

Relative Humidities as Accumulated Percent-days Related to Some Indiana Plant Disease Problems. R. W. SAMSON, Purdue University.—In attempts to correlate Indiana summer weather factors with outbreaks and severity of certain vegetable diseases it was found convenient and instructive to handle relative humidity data in terms of accumulated percent-days, one percent relative humidity for one day being one percent-day. Accumulated percent-days were calculated from U. S. Weather Bureau records (Climatological Data, Indiana Section) for June, July, August and September of each of the years from 1915 to 1959. When histograms are constructed from this data separately for each of the 45 growing seasons and arrayed as departures from a longtime average a gross but striking graphic portrayal of summertime relative humidity appears. The 45-summer period was characterized by the particularly humid summer of 1915, followed by 27 summers, none particularly humid and most much below the longtime average. The succeeding 18 summers were mostly much above average in total percent-days. The impact of the resulting increased severity of certain diseases during the latter more humid period is partially reflected in recent abandonment of many Indiana tomato canning factories that were built in the earlier period and in the decline of a muskmelon growing industry that flourished from 1916 to 1941 in southern Indiana.

The Culture of *Erysiphe cichoracearum* DC. upon Detached Leaves of *Zinnia* and *Helianthus*. RALPH M. MORRISON, Indiana University.—The

Erysiphaceae belong to the order *Erysiphales* of the class *Ascomyceteae*. The genera of this family grow as obligate parasites upon a large number of dicotyledons belonging to several different families. The taxon reported upon here, *Erysiphe cichoracearum* DC., parasitizes a number of genera in the *Compositae*. Before any detailed study of these organisms can be made, it is necessary that a culture method be utilized which will minimize both biological variation as well as environmental variation. Detached leaf culture proved to be the best method to accomplish this goal. Methods of culturing leaf disks of *Zinnia* and *Helianthus* are discussed. Types of sustaining media and environmental conditions necessary for the maintainance of leaf-mildew cultures are discussed with a view toward determining the factors influential in the sexual as well as the asexual phases of mildew development.

Culture of Powdery Mildew (*Erysiphe graminis* D. C.) on Excised Wheat Leaves in Solutions of Benzimidazol. RALPH M. CALDWELL, Purdue University.—The study and maintenance of pure cultures of the powdery mildew fungus have been difficult owing to the contamination between pure cultures in the greenhouse and the rapid loss of conidial viability in storage. As shown by Person, Samborski and Forsyth, excised wheat leaves can be maintained for relatively long periods if floated on or the cut ends are immersed in solutions of benzimidazol. Two races of *Erysiphe graminis* have been carried in pure culture through 9 transfers on wheat leaves so maintained in petri dishes in 40 or 60 p.p.m. of benzimidazol in distilled water. The cultures grew vigorously either in north window daylight or under fluorescent supplemented with Mazda illumination. The characteristic resistant or susceptible reactions of the wheat varieties, Michigan Amber and La Porte, were maintained under these conditions. Plastic petri dishes with center dividers to hold all but the cut ends of the leaves out of the solutions were well adapted for this purpose. Under these conditions, at temperatures of 60 to 75 F., the fungus sporulated luxuriantly and provided abundant conidial inoculum for experimental use. Transfers were necessary every 3 to 4 weeks.

A Comparative Pollen Study of Two Early Wisconsin Bogs in Indiana

DONALD W. ENGELHARDT, Indiana University

The reconstruction of past vegetation involves, as does any type of research on pre-historical material, numerous sources of error and omission. Yet an attempt at the reconstruction is necessary if we are to understand the changing environment of the past or to interpret the modern vegetation. Inference, as far as possible, should be made by investigating the direct evidence in the form of organic remains whose sequence and identity can be resolved. By the means of pollen studies it is possible to venture estimates of the changes in the ecological conditions that occurred between the various glacial periods.

For the past three decades, pollen analysis has been the dominant method of investigation of late Quaternary vegetational and climatic development. Weaver and Clements (12) state that the climax community is the product of the climate and controlled by it. The climax is not merely the response to a particular climate, but it is at the same time an expression of it. The vegetation integrates the climatic factors and expresses them in terms of life forms.

Because Indiana has both glaciated and unglaciated regions, this state is of special interest in tracing the possible climatic conditions which prevailed since the retreat of the continental ice sheets. According to Malott (6) approximately 30,100 square miles of Indiana have been subjected to glaciation, while only about 6,250 square miles have not been covered by the ice. The unglaciated area is in the middlewestern portion of the southern third of the state and is frequently spoken of as the driftless area, as opposed to the glaciated area. Four major glacial periods are recognized in Indiana: the Kansan, the Illinoian, the Early Wisconsin (Tazewell), and the Late Wisconsin (Cary). Since neither of the successively later ice sheets extended as far south as the one that preceded it, there is a wide belt of the three latter periods. The Illinoian deposits overlapped the Kansan drift in Indiana (11). The border line between the Illinoian and Early Wisconsin glaciations runs from northern Vigo County in the west to southern Franklin County in the east.

Location and Description of Bogs

The two bogs that are discussed in this paper are in the area of the Early Wisconsin glaciation. These sites are: the Fox Prairie Bog, 3 miles north of Noblesville in Hamilton County; and Bacon's Swamp, on the north side of Indianapolis in Marion County. Both bogs have been previously studied during the late 1930's by students of Dr. John E. Potzger. Now, by improved methods, the bogs have been reanalyzed using smaller intervals, and to a greater depth than had been reached before.

The Fox Prairie Bog (Fig. 1) is located in an old valley or glacial channel on the west side of the West Fork of White River (5). The surrounding country varies from a relatively level till plain to an undulating somewhat hilly topography. The area of the bog is approximately 150

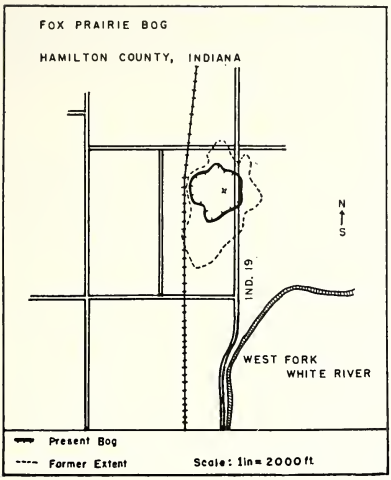

Fig. 1

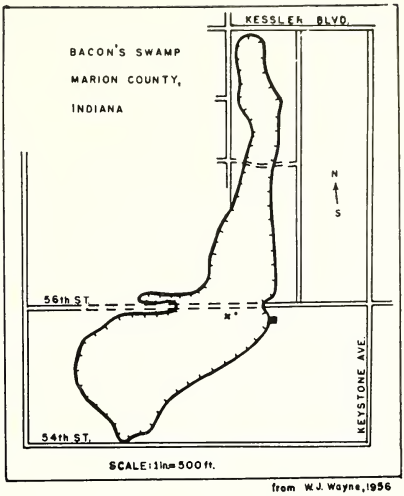

Fig. 2

Figure 1. Fox Prairie Bog, Hamilton County, Indiana adapted from U. S. G. S. Noblesville quadrangle map, 1953.

Figure 2. Bacon's Swamp, Marion County, Indiana, adapted from W. J. Wayne map of Bacon's Swamp.

acres, as determined from the Noblesville quadrangle map. This bog is believed to be one of the deepest in Indiana. Prettyman (8) attained a depth of 41 feet near the center of the bog in the winter of 1936-37. The boring made by a class from Indiana University in February 1957 reached a depth of 13.02 meters, or about 42.7 feet, at a position slightly east of the center of the present bog. The fact that this bog is over 40 feet deep is striking, as the surrounding area would not suggest the presence of a lake that deep. Fox Prairie bog is one of the so-called kettle holes that was created by the ablation of a former mass of glacier ice that was wholly or partly buried in the drift. Most kettles are less than 8 meters deep, but some exceed 45 meters (2). The lakes thus formed by the melting ice are rather deep, but are usually not extensive bodies of water.

Bacon's Swamp (Fig. 2) is the name given to an area that is actually a peat bog of the kettle hole type, and is not a true swamp. According to Potzger (9), "A swamp is a feature of the topography where the water table is above the surface and the soil is inorganic or of a humus nature." A bog is, however, "a feature of the topography where the water table is at or near the surface and the soil is of organic origin formed *in situ*." Therefore, Bacon's Swamp is, according to this definition, a true bog. It is located in a unique position for this study in that it is on the southern limits of the Early Wisconsin bog area in Indiana. The area of the bog is approximately 30 acres and it is at present covered with water. In the winter of 1936 the students of J. E. Potzger made their deepest boring, 32 feet. This boring was made at a point about 250 feet from the east

shore and 100 feet south of the old roadbed of Fifty-sixth Street (7). In April, 1959, students under the direction of D. G. Frey made a boring in about the same position and attained a depth of 11.92 meters or about 39.6 feet. At this level coarse unsorted sand was found.

Methods

A 13.02 meter core from the Fox Prairie Bog was collected in meter long segments by means of a Livingstone piston sampler. From the surface of the sediment to the 7.15 meter level, peat of varying composition was found. The core from this level to the final depth was composed of lake sediments of gyttja, silt, clay, and sand.

The core from Bacon's Swamp was also collected in meter long segments by the means of the Livingstone piston sampler down to a depth of 10 meters; from this point a Hiller borer was used to the total depth of 11.92 meters. Samples were taken every 50 cm. until coarse unsorted sand was reached. From the surface to the 6.80 meter level, peat of varying composition was encountered, and from this point to the final depth, lake sediments of gyttja, silt, clay, and sand were found. No marl was found in the lower levels as was reported by Prettyman (8) and Otto (7).

Samples, approximately 1 cc in volume, were taken from the center of the peat sections of the cores and placed in 250 ml. beakers with 10% KOH and then heated with constant agitation by the means of a mechanical stirrer until the sediment was completely deflocculated (ca. 8-10 min.). Next, the samples were centrifuged and washed with water, followed by screening with a 70 mesh screen (208 micron openings) to remove the larger particles. The material was then mounted in glycerine jelly stained with basic fuchsin. The samples taken from the lake sediment sections of the cores were first treated with 10% HCl to test for the presence of carbonates. There was little or no CO_2 evolved. The samples were then centrifuged and washed with distilled water and treated with 10% KOH until completely deflocculated, after which they were centrifuged and washed with distilled water. In the lower levels analyzed which contained a considerable amount of silt, clay, and sand, the bromoform-acetone method of differential flotation (3) was employed to concentrate the pollen grains. From the Fox Prairie Bog, 72 levels were analyzed; 65 levels were analyzed from Bacon's Swamp.

The slides were examined systematically and all the pollen and spores encountered were identified and tabulated until at least 200 tree pollens were recorded. The actual number of grains per sample ranged from 182 to 332 for the Fox Prairie Bog, and 151, in the lowermost level, to 444 for Bacon's Swamp. The non-arboreal pollens and spores were not identified as to genera for the diagrams, but were placed in botanical family categories such as Graminae, Compositae, Chenopodiaceae, etc.

In the pollen diagrams all trees and shrubs are included in the pollen sum, and the other plants are expressed as percentages of this sum at each level studied.

RESULTS OF ANALYSES

Fox Prairie Bog

The lowermost levels of the Fox Prairie Bog (Fig. 3) are characterized by a high percentage of *Picea* with a small percentage of *Abies*

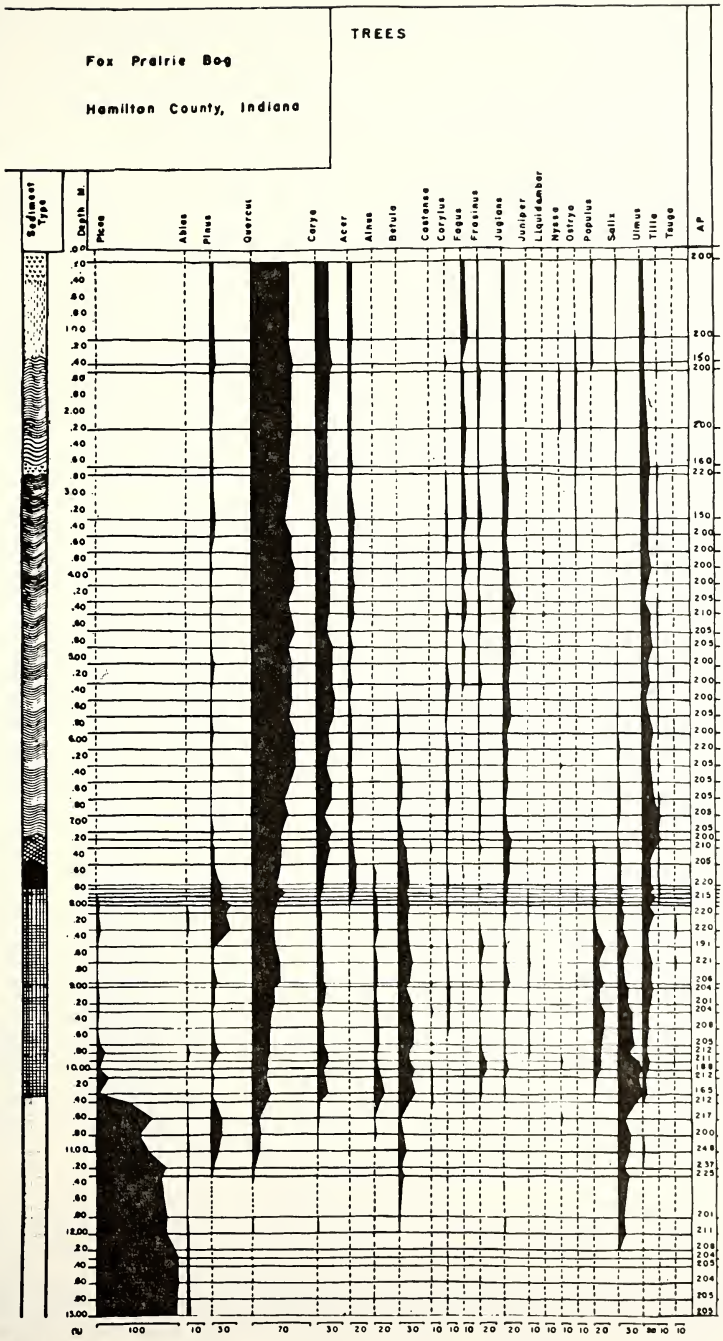

Figure 3. Pollen Spectrum from Fox Prairie Bog, Hamilton County, Indiana

and the total absence of other arboreal genera. *Picea* reached a maximum of 98% at the 12.6 and 12.3 m levels. From this maximum *Picea* declined steadily to 37.5% at the 10.4 m level, and then suddenly dropped to 1.3% at 10.3 m. The percentage rose to 12% at 10.1 m and then declined to low percentages (less than 2%) until the 8.3 m level, where it increased to 3.6%. It then decreased in percentage and disappeared from the spectrum at 7.8 m.

Abies occurred in low percentages in conjunction with *Picea* and disappeared from the spectrum at the 10.3 m level, which coincided with the sudden drop in *Picea*. *Abies* reappeared briefly at the 9.8, 8.3, and 8.1 m levels, and then was no longer found in the spectrum.

Pinus appeared at the 11.2 m level and reached a minor peak of 12.1% at the 10.8 m level. It then declined, with minor fluctuations, followed by a rise to a peak of 24.7% at 8 m. The percentage then decreased but remained, in negligible amounts, in the spectrum up to the surface of the bog.

Tsuga appeared in low percentages in only three levels, 8.7, 8.3, and 8.1 m, which coincided with the *Pinus* maximum and the increase in *Picea* and the reappearance of *Abies*.

Quercus appeared at the 12 m level and rapidly increased to 21.9% at 10.3 m, where the sudden drop in coniferous pollen occurred. It then increased to a maximum of 60.4% at the 6.3 m level and proceeded to decline, with minor fluctuations, to 48% at the surface.

Other genera, namely, *Alnus*, *Betula*, *Carya*, *Fraxinus*, *Juglans*, *Populus*, *Salix*, and *Ulmus*, appeared between the 12 and 10 m levels, in the interval between the decline of the *Picea-Abies* maximum and the *Pinus* maximum. The pollen grains of *Quercus*, *Carya*, *Juglans*, *Ulmus*, and *Salix* comprise the major percentage of the deciduous pollens encountered. *Acer* does not appear in the spectrum until after the decline of the *Pinus* maximum, and *Fagus* appears late in the spectrum, at the 5.3 m level, and continues to the surface of the bog.

Altogether there were 22 arboreal genera identified in the deposits of Fox Prairie Bog.

The nonarboreal pollens (NAP) were counted and placed in their proper botanical families. Of the 13 families encountered, 5 belonged to families of aquatic plants. Spores of lycopods and polypodiaceous ferns were distributed in small percentages throughout the entire spectrum.

The grains identified as *Equisetum* occurred almost continuously in the spectrum. This large grain had a distinct two-layered cell wall, a diagnostic feature which distinguishes it from the superficially similar pollen of *Larix*. It is significant that no grains of *Larix* were positively identified in this study, although Prettyman (8) had previously reported a maximum of 28% *Larix* from the Fox Prairie Bog.

Bacon's Swamp

In the lower levels of Bacon's Swamp (Fig. 4), as in the Fox Prairie Bog, *Picea* was the dominant arboreal genus, with low percentages of *Abies* and *Pinus* also being present. *Picea* attained a maximum of 95.6% at the 10.7 m level and then underwent a steady decrease in the percentage, with minor fluctuations, to 41.8% at 6.9 m. At this level *Picea* suddenly

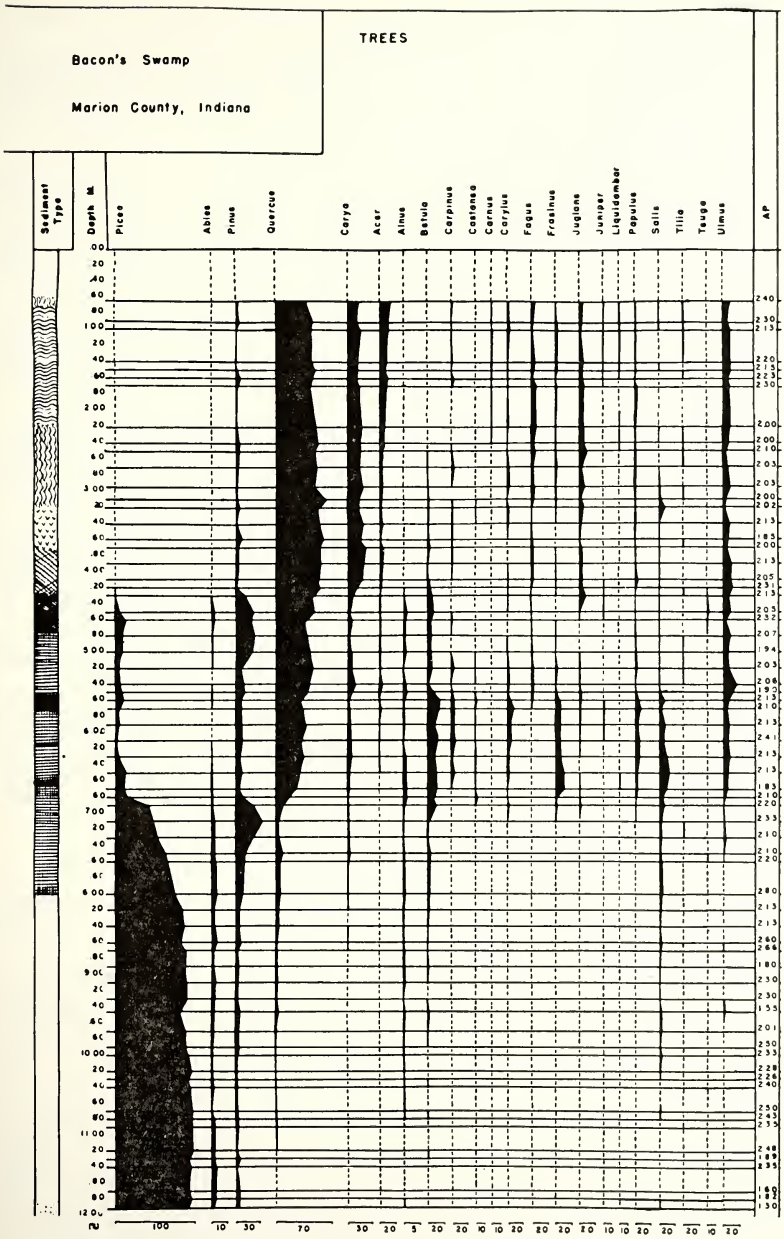

Figure 4. Pollen Spectrum from Bacon's Swamp, Marion County, Indiana.

declined to 15.2%, and then continued to decrease to less than 1% at 6.1 m. *Picea* remained in the spectrum in low percentages until it rose to a

secondary peak of 13.4% at 4.6 m; from this point it declined rapidly and was absent from the spectrum above 4.1 m.

Abies never attained a dominant position in the spectrum, but remained in the spectrum in low percentages (5% maximum) until the 6.3 m level, where it disappeared. *Abies* reappeared at 5.2 m and rose to 1.9% before it dropped from the spectrum.

Pinus was present continuously in the spectrum and attained two maxima. The first occurred at 7.1 m (33.6%) in conjunction with the decline of the *Picea* maximum. The second peak of 23.1% coincided with the increase of *Picea* and the reappearance of *Abies* at the 4.8 m level. The percentage of *Pinus* then decreased, but remained in the spectrum to the surface of the bog.

Tsuga appeared, but in low percentages, in four levels only. The first level at 7:5 m, where the first *Pinus* maximum occurred, and the other three levels, 4.8, 4.6, and 4.5 m, which coincided with the coniferous pollen increase as it did in the Fox Prairie Bog.

Quercus appeared at the 11.2 m level and remained in low percentages to the 6.8 m level, where it increased rapidly as the first *Pinus* maximum decreased. *Quercus* reached a maximum of 59.4% at the 3.6 m level and then declined, with minor fluctuations, to 39.2% at the surface.

As in the case of the Fox Prairie Bog, the other eight major deciduous genera appeared at the decline of the *Picea-Abies* maximum and a *Pinus* maximum. *Acer* appeared at the 6.5 m level and increased to 14.1% at the surface.

There were 22 arboreal genera identified in the deposits from Bacon's Swamp.

The types and percentages of nonarboreal pollens and spores were similar to those found in the Fox Prairie Bog. Furthermore, *Equisetum* spores were detected in similar percentages and depths as in the previously described bog. No grains of *Larix* were positively identified in the deposits as was reported by Otto (7).

Discussion

The results obtained from the analysis of the two bogs exhibit a striking resemblance, even though the Fox Prairie Bog is more than 25 miles north of Bacon's Swamp.

The lower levels of the Fox Prairie Bog and Bacon's Swamp are characterized by a high percentage of *Picea* and a low percentage of *Abies*. The *Picea-Abies* climax in the lower levels of the bogs has been found in most of the bogs studied in Indiana (10). The period of cool, moist climate which continued for a time after the Early Wisconsin glacial retreat, which occurred about 20,000 years B.P. (Before Present) in this area, was evidently responsible for the dominance of the *Picea-Abies* forest. This cool, moist period must have continued longer than the interval of the retreat of the Early Wisconsin glacier. However, this cooler climate must have extended to the period following the retreat of the Late Wisconsin glacier (about 12,500 years B. P.), because there is no evidence of a warm period between the two glacial advances. If there had been a change in the climate in this interval between the two glacial advances it is probable that a deciduous forest would have appeared.

Moreover, it is postulated that this deciduous forest would have been superseded by a coniferous forest, due to the periglacial effects caused by the advance of the Late Wisconsin substage (about 13,600 years B. P.) to within 30 miles of the present site of the Fox Prairie Bog. Following the northerly retreat of the Late Wisconsin glacier, the climate became warmer and drier and the *Picea-Abies* climax suddenly declined in the pollen profile.

In both bogs *Pinus* reached a peak during the decline of the *Picea-Abies* climax. The *Pinus* then decreased in the transitional period, which is characterized by the appearance of the deciduous forest genera, especially by the rapid increase of *Quercus*. This appearance of a deciduous forest would seem to indicate a somewhat warmer, drier climate. In this interval there is almost the complete elimination of *Picea* and *Abies* and a marked decrease in *Pinus* coupled with the marked development of *Betula*, *Salix*, *Fraxinus*, *Populus*, etc.

Pinus, *Picea*, and *Abies* make a notable increase in both bogs after this interval at levels approximately two meters apart. It is at this time that *Tsuga* appeared in both bogs. This coniferous increase points to a change to a cooler, more moist climate such as existed earlier. Frey (4) has recognized what may be the Two Creeks Interval in Indiana pollen diagrams. This interval occurred when the ice retreated into northern Michigan (or beyond) about 11,500 years B.P. If the interval between the two *Pinus* maxima, where there is a distinct development of *Quercus*, *Betula*, and the *Salix-Populus* group, is interpreted as the Two Creeks Interval, then the increase of the coniferous trees may be due to a cooler, more moist climate caused by the Valders advance about 10,000 years B. P. Since the Valders advance did not reach Indiana, the effect of the readvance of glaciation would probably have only a minor effect on the bogs in the southern half of the state, as is indicated by the short period of coniferous increase. With the retreat of this glacial advance, the Midwest was not again covered by ice.

Following the period of cool, moist climate caused by the readvance of the ice, there was a change to a warm, drier climate in which the deciduous forest increased rapidly. *Quercus* attained a dominant position in association with *Carya*. This *Quercus-Carya* climax has existed in the pollen profile to the surface of both bogs. There is an indication, however, of a change to a warmer, more moist climate, because in both bogs *Acer* and *Fagus* have increased and the *Quercus-Carya* maximum has decreased slightly.

Summary

To summarize this study, it may be stated that the results obtained from the analysis of the Fox Prairie Bog and Bacon's Swamp exhibit a striking resemblance. The lower levels are characterized by a *Picea-Abies* climax with a *Pinus* maximum at the decline of this climax. In the following interval, which may be interpreted as the Two Creeks Interval, there is a rapid and distinctive increase of the deciduous forest genera. The second *Pinus* maximum, in conjunction with *Picea*, *Abies*, and *Tsuga*, then occurs to close this interval. This coniferous increase may be due to the climatic effect of the Valders advance. After the decline of the conifers, *Quercus* and *Carya* become dominant and continue to the surface as

the climax association. *Acer* and *Fagus* increase near the surface indicating another possible climatic change.

The post-glacial forest succession of *Picea-Abies* to *Pinus* to the deciduous forest complex to *Pinus-Picea-Abies* to *Quercus-Carya* to *Acer-Fagus* suggests the following climatic periods: cool moist to cool drier to warmer drier, changing to cool moist again, and then to warm drier and finally to warm more moist.

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Pectodictyon and Other Unusual Algae from Indiana

C. Mervin Palmer, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, and Earle Brown, Water Treatment Plant, Salem, Indiana

Lake Salinda is the water supply reservoir for Salem in Washington County, Indiana. Water samples collected over a period of several months by Earle Brown, Superintendent of the water treatment plant, have contained a number of unusual and interesting algae. One of these was a *Scenedesmus*, present in fair abundance in early May, that contained a single spine on each terminal cell. It represents a variant of *S. opoliensis*. In the same water sample was a colonial green alga belonging to the genus *Tetrallantos*. Other better known algae present in the reservoir at the time included *Dictyosphaerium pulchellum*, *Kirchneriella contorta*, *Westella linearis*, *Phacus pyrum*, *Ankistrodesmus falcatus*, *Pediastrum duplex*, and *Crucigenia quadrata*.

Certain algae found in Lake Salinda at other times were even more unusual, such as the blue-green alga *Borzia*, the colonial desmid *Cosmocladium*, and the colonial green alga *Pectodictyon*. These are described in some detail below.

Tentative identification of the algae from Lake Salinda was made at the laboratory of the water treatment plant in Salem and the samples were then forwarded to Cincinnati for further study.

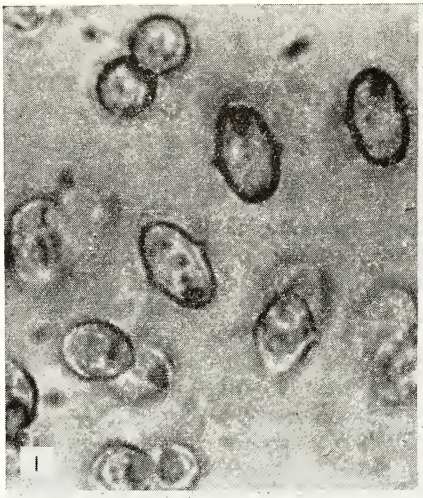
In February 1959, an unusual alga was observed on a pond in Dubois County by Grover Cook, Stream Biologist, Indiana Stream Pollution Control Board. A preserved sample containing specimens of this organism was sent to Cincinnati, where the alga was identified as the pigmented flagellate, *Hymenomonas*.

A comparatively rare blue-green alga *Pseudanabaena* that was collected in Cincinnati in March, is also included in the description which follows:

Cosmocladium tuberculatum Prescott. Figures 1, 2.—Collected by Earle Brown, May 22, 1959, and during June and July, in Lake Salinda, Salem, Indiana. Each cell has a deep, wide sinus almost dividing the cell in two. Two lateral protuberances are present on each semi-cell. A mucilaginous strand fastened to the isthmus, and with occasional branches, unites the cells to form a colony. This desmid as a genus has been reported only a few times in this country. The species, originally described from Michigan (8) has been recorded also for Mississippi (9).

Borzia trilocularis Cohn. Figures 3, 4.—Collected by Earle Brown, June 1, 1959, in Lake Salinda, Salem, Washington County, Indiana. All of the American reports for this alga are limited to Indiana, it having previously been reported for Montgomery Co. (10) and Cass Co. (2).

Pseudanabaena catenata Laut. Collected by A. E. Lemke, March 27, 1959, in a fish aquarium, Sanitary Engineering Center, Cincinnati, Ohio. It is a planktonic organism forming a visible blackish blue-green growth. Dried herbarium mounts are light purplish. Dr. Francis Drouet examined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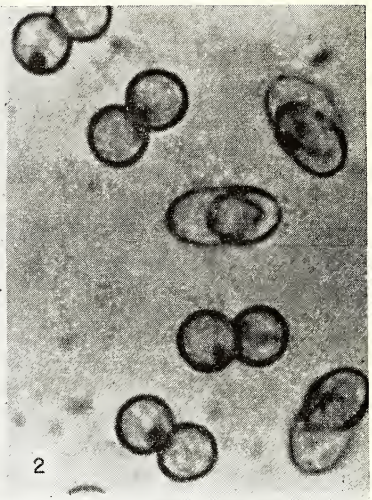
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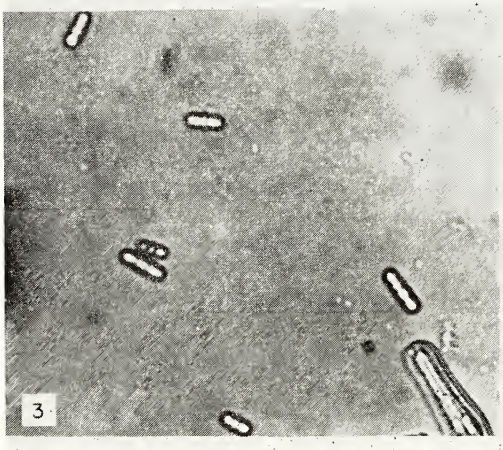
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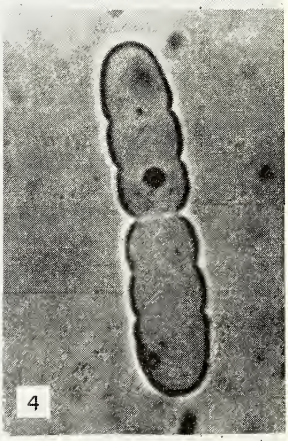
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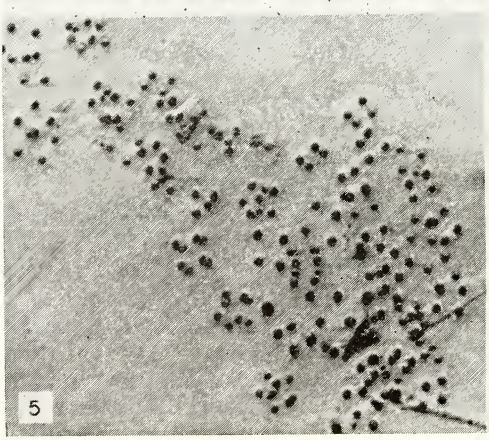
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mounts made from the dried herbarium material and considers the organism to be bacterial and not algal. At Cincinnati, when inoculated into an inorganic algal culture medium, the organism developed an abundant growth with a blackish blue-green color and settled to the bottom of the flask. This genus probably has no previous record for this country (3).

Pectodictyon cubicum Taft. Figures 5, 6.—Collected by Earle Brown, February 2, 1959, in Lake Salinda, the water supply reservoir for Salem, Washington County, Indiana. The alga was first recognized on February 16 in the sample which had been kept indoors since collection. The spherical cells are held at the corners of a cube formed by colorless, gelatinous strands. In older colonies several cubes are joined together. Each cell is capable of dividing and developing to form a new cubical colony. The original description for this genus and species was reported by C. E. Taft for Ohio in 1945 (11). Prescott indicates that it has been reported once since that time (7).

Hymenomonas roseola Stein. Collected by Grover Cook, February 25, 1959, from a pond on Purdue Forage Farm, Dubois County, Indiana. The organism had been present in large numbers for six weeks. Specimens sent to the senior author for identification were preserved in formalin. As previously noted by Lackey (6), these organisms are changed in color and shape by the preservative. This pigmented flagellate has oval "coccoliths" surrounding the protoplast. It belongs to the Class Chrysophyceae and in this country has been reported previously only from Ohio (5).

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1. *Cosmocladium tuberculatum* Prescott. End view showing lateral protuberances on semi-cells. (x 1500).
2. *Cosmocladium tuberculatum* Prescott. Front view showing isthmus and sinus. (x 1500).
3. *Borzia trilocularis* Cohn. Several colonies showing range in number of cells (x 250).
4. *Borzia trilocularis* Cohn. Single colony of six cells. (x 1500).
5. *Pectodictyon cubicum* Taft. Compound colony of numerous cubical coenobia. (x 150).
6. *Pectodictyon cubicum* Taft. Small colony stained to show gelatinous strands arranged as a cube. (x 300).

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Studies in Indiana Bryophytes XII

WINONA H. WELCH, DePauw University

Since the publication of Mosses of Indiana, July 23, 1957, by the author, the following species, not included in the manual, have been collected in the state. Although the list of names was published by H. A. Miller and J. W. Thomson, in their foray report in The Bryologist (1959), two of the species had been collected previously, after the manual manuscript had been submitted to the publisher and before the American Bryological Society 1958 Foray in Indiana.

Specimens of the collections cited are in the Herbarium of DePauw University. Unless otherwise stated, the nomenclature is that of A. J. Grout, Moss Flora of North America North of Mexico.

The total number of known species of mosses in Indiana is now 221, varieties 35, and forms 9, representing 95 genera and 26 families.

Ditrichaceae

Ditrichum lineare (Sw.) Lindb. (Fig. 1.) According to statements by H. S. Conard and A. J. Grout, *D. pusillum* and *D. lineare* may grow together and many intermediate forms may occur. *D. lineare* differs from *D. pusillum* and *D. pallidum* by the following combination of characteristics: Stems frequently bearing innovations or offshoots; leaves 1-1.5 mm. long, costa strong, generally percurrent, occupying ⅓-½ of width of acumination, margins very slightly serrulate to entire, very narrowly revolute, leaf apices canaliculate, blunt; awn of perichaetial leaves much shorter than the long-sheathing base; dioicous; seta and capsule erect, operculum short conic, 0.5 mm. long, urn cylindric and subcylindric, usually about 1.5 mm. long, occasionally up to 1.75 mm. in length, often somewhat wrinkled or longitudinally grooved when dry, annulus frequently one row of large cells above two rows of small cells, peristome teeth irregularly divided, sometimes forked to base, frequently united above; spores 15-18μ in diameter, smooth, maturing in late autumn or in winter.

Habitat: On clayey or sandy soil, especially on freshly exposed clay.

Indiana distribution: Putnam County, Hoosier Highlands, Sandstone Gulch (H. A. Miller *5776, 5777, 5817 A*, Aug. 24, 1958).

Seligeriaceae

Seligeria calcarea (Hedw.) BSG. (Fig. 1.) Dr. Conard's statements are so appropriate for these plants that the author has copied them. "These tiny mosses grow in velvety coatings on cool, shaded rocks, often in deep crevices. They are barely visible, and must be scraped off the rock with a knife."

Plants minute, gregarious; stems usually less than 1 mm. high; leaves up to 1 mm. long, abruptly narrowed from a concave, oblong base into a linear, subulate, subobtuse to obtuse apex, costa indistinct, flattened, filling the apex, margins entire or nearly so; seta erect, up to 2 mm. long, capsule erect, minute, operculum shorter than urn, the urn about 0.5 mm. long, with neck distinct, oval to pyriform when young, turbinate in age, peristome teeth 16, undivided, without median line, fragile; spores smooth, 8-10μ in diameter, mature in spring or summer.

Habitat: On calcareous rocks.

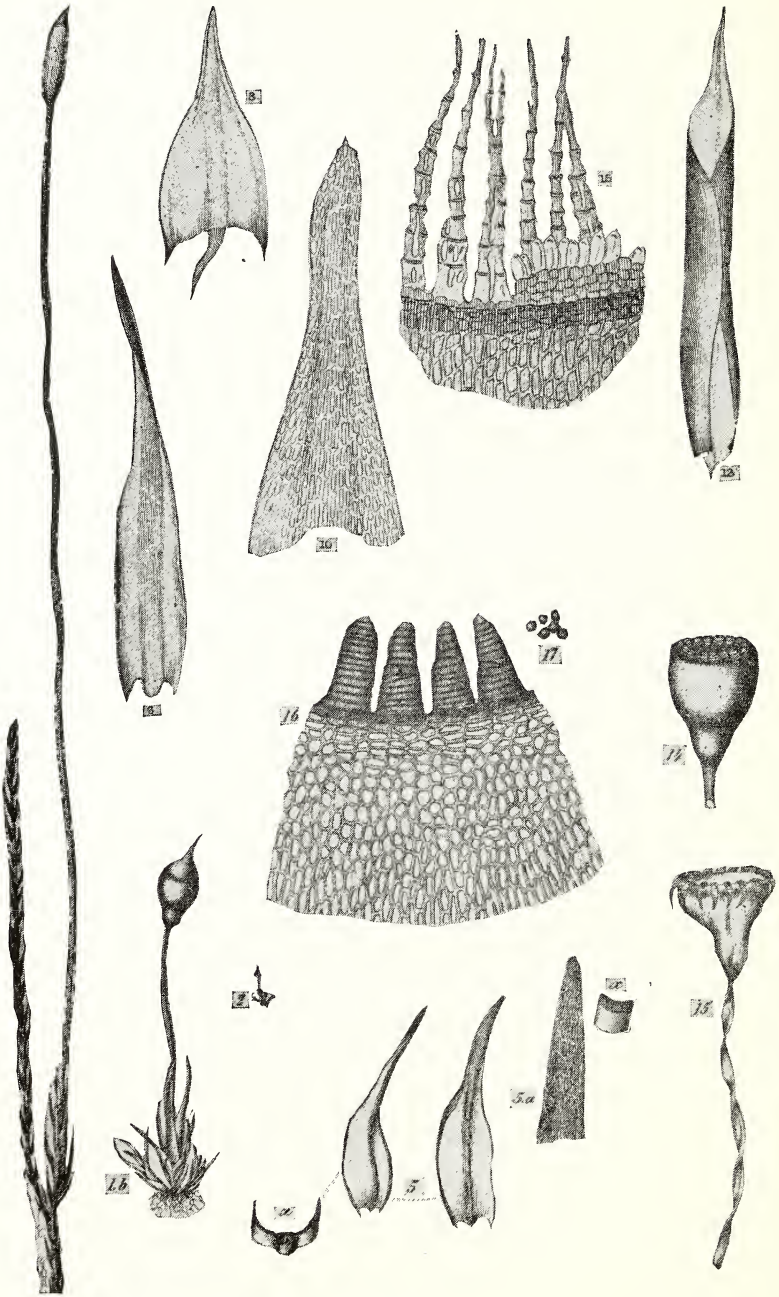

Figure 1

Indiana Distribution: Putnam County, Hoosier Highlands (Paul L. Redfearn, Jr. and Richard D. Houk *3933*, Aug. 24, 1958).

Dicranaceae

Brothera leana (Sull.) C. Müll. (Fig. 2.) Plants in low, dense, whitish green or straw-colored mats, stems erect, up to 1 cm. high, thickly foliate, frequently bearing in axils of upper leaves head-like clusters of numerous, deciduous, small, rudimentary leaves or fusiform brood-bodies or gemmae, leaves channeled, lanceolate-subulate, up to 3.5 mm. in length, costa broad, filling most of upper portion of blade, occupying ⅓-⅞ of lower part of leaf, in cross section near middle of blade, consisting of 3 layers of cells, the cells of upper and lower layers similar and slightly larger than the cells of the middle layer, without distinct stereid band, margins entire throughout or slightly denticulate at apex. [Dr. Grout, in Moss Flora of North America, states that North American plants are sterile. R. S. Williams, in North American Flora, describes the fruit from a specimen collected in Japan.]

Habitat: On bark of trees or rotten logs and stumps, or on humus in shaded places; in Indiana, on sandstone.

Indiana distribution: Parke County, Turkey Run State Park (Zen Iwatsuki, Leo Koch, and A. J. Sharp *1806*, Nov. 29, 1957); Putnam County, Hoosier Highlands (Paul L. Redfearn, Jr. and Richard D. Houk *3953*, Aug. 24, 1958; Winona H. Welch *17905*, Aug. 24, 1958).

Pottiaceae

Eucladium verticillatum (Brid.) BSG. (Fig. 2.) Plants in dense tufts, pale glaucous-green above or yellowish green, often covered with encrusted lime and whitish; stems generally 1-5 cm. high, freely branching, fragile; leaves linear-lanceolate to linear subulate, up to 2.5 mm. long, crispate when dry, costa broad, sometimes ⅓ of width of blade, disappearing in apex, or percurrent to briefly excurrent, apices acute or apiculate because of excurrent costa, margins plane, toothed just above the base at the meeting of the chlorophyllose cells and the hyaline basal cells, upper cells of leaves papillose, with thick walls, rectangular, quadarate, irregular, or rounded, 7-12μ in longest diameter; sporophyte erect, seta 1-2 cm. long, urn bearing 16 papillose, peristome teeth.

Habitat: On calcareous rocks.

Indiana distribution: Monroe County, Cascades Park, near Bloomington (Winona H. Welch *17487*, July 5, 1956); Putnam County, Vermillion Falls, near Greencastle (Winona H. Welch *17912*, Aug. 23, 1958).

Sterile plants of *Eucladium verticillatum* may be collected for species of *Gymnostomum*. The serration on the leaf margins of *Eucladium* will distinguish that genus from the entire margins of *Gymnostomum*. The presence of a peristome in *Eucladium* and its absence in *Gymnostomum* is also a distinctive characteristic.

During the past year (1958-59), Dr. Lewis E. Anderson, Duke University, has carefully examined the author's collections of *Gymnostomum*

Fig. 1. *Ditrichum lineare* (from Grout, MFNA *1*: *pl. 28 A*; from Sullivant, Icones Musc. *pl. 28*). On left, gametophyte with innovation and sporophyte, enlarged; 6, leaf; 8, lower leaf; 10, leaf apex; 13, perichaetial leaf; 15 (upper), portion of urn, peristome, and annulus. *Seligeria calcarea* (from Grout, MFNA *1*: *pl. 34*; from Bry. Eur. *pl. 110*). 1b, plant enlarged; 2, plant; 5, stem leaves; 5a, leaf apex; 14, 15 (lower), capsules; 16, portion of urn and peristome; 17, spores.

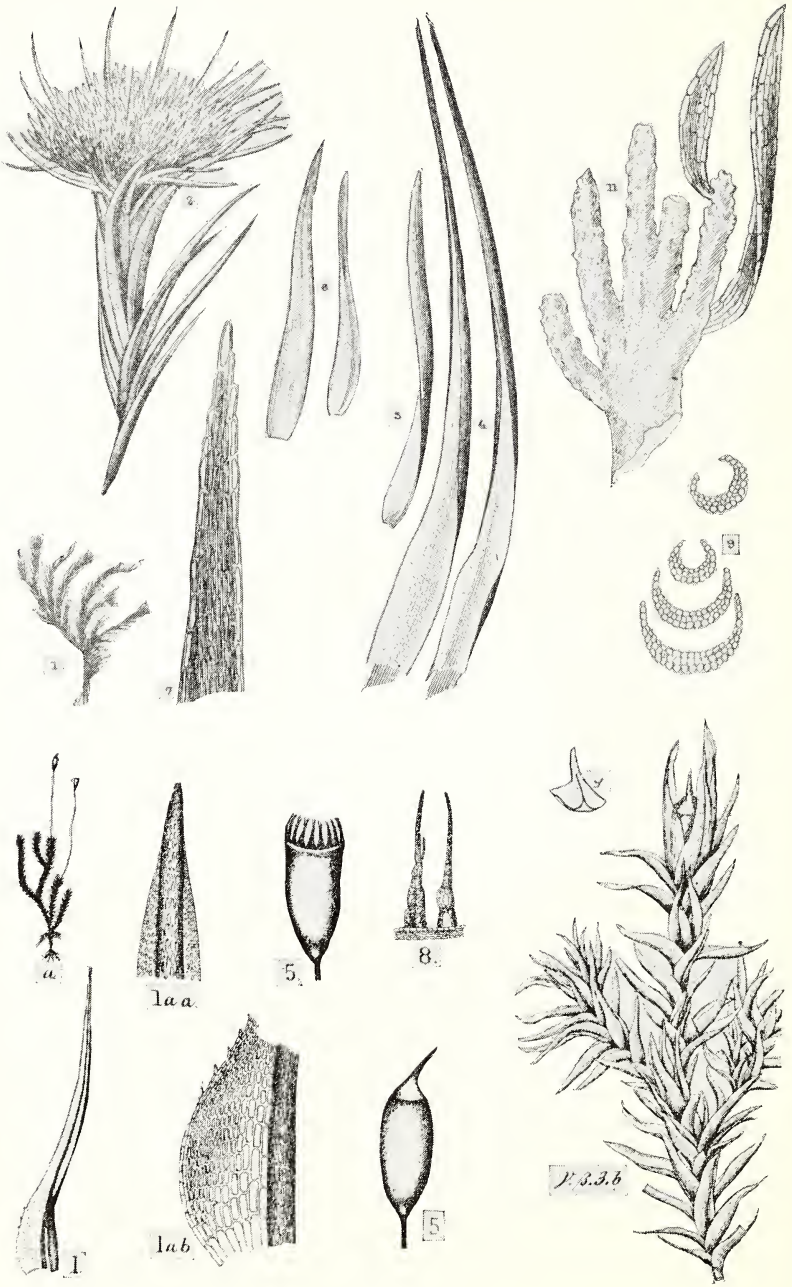

Figure 2

calcareum, cited in the Mosses of Indiana. He regards them, instead, to be *G. aeruginosum*, in accord with the studies published in 1956 by Crum and Anderson.

Grimmiaceae

Grimmia apocarpa Hedw. var. *alpicola* (Hedw.) Hartm.* (Fig. 2.) The var. *alpicola* differs from the species, *apocarpa*, in the following combination of characteristics: Plants commonly pulvinate, leaves ovate-lanceolate or lanceolate, 1.5-3 mm. long, apices acute or obtuse, muticous, calyptra cucullate, capsule ovate, spores 16-20μ in diameter, mature winter to spring.

Habitat: On various rocks.

Indiana distribution: Putnam County, Vermillion Falls, near Greencastle (H. A. Miller *5598*, *5604*, Aug. 23, 1958), Hoosier Highlands (H. A. Miller *5648*, Aug. 24, 1958).

Note: As to the reports of *Atrichum crispum* and *A. macmillani* (The Bryologist 62: 72. 1959), the author regards one of the collections reported as *A. crispum* to be *A. angustatum* and the other to be *A. undulatum*, and the collection reported as *A. macmillani* to be *A. angustatum*.

The illustrations are taken, with permission, from Grout, Moss Flora of North America North of Mexico, and from Conard, How to Know the Mosses (1944).

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* According to Sayre (1952), *G. apocarpa* var. *alpicola* replaces *G. alpicola* Hedw. and includes *G. alpicola* var. *rivularis* (Brid.) Broth., f. *papillosa* Jones, and var. *latifolia* (Zett.) Möller, as presented by Jones (1933), in Grout, Moss Flora of North America.

Fig. 2. *Brothera leana* (from Grout, MFNA 1 :*pl. 50* ; from Sullivant, Icones Musc. *pl. 18*). 1, plant natural size ; 2, plant, much enlarged ; 4, 5, 6, leaves ; 7, leaf apex ; 9, cross sections of leaf ; 11, branches of upper portion of stem, with rudimentary leaves which are assumed to function as brood bodies. *Eucladium verticillatum* (from Grout, MFNA 1 : *pl. 79 C ;* from Braithwaite, Brit. Moss Fl. 1 : *pl. 35 C.* a, plant, natural size ; 1, leaf, much enlarged ; 1aa, leaf apex ; 1ab, portion of leaf base, both enlarged ; 5 (lower), capsules, enlarged ; 8, peristome teeth, enlarged. *Grimmia apocarpa* var. *alpicola* (from Grout, MFNA 2 : *pl. 2 ;* from Bry. Eur. *pl. 234*). On lower right, plant enlarged ; g., cucullate calyptra, enlarged (from Conard. HKM. *fig. 73*).

Septoria Leafspot Disease of *Mentha* spp.[1]

Ralph J. Green, Jr. and Keiji Sawada, Purdue University

Peppermint (*Mentha piperita* L.) and common and scotch spearmints (*M. spicata* L. and *M. cardiaca* L.) are important crops in the muckland region of northern Indiana. At present, more than 18,000 acres are devoted to these crops with peppermint accounting for from 10 to 12,000 acres (3). The limiting factor in the production of the mints in Indiana is a soilborne disease called *Verticillium* wilt (3). Peppermint is damaged much more severely than spearmint and many growers plant spearmint when it is no longer profitable to produce the more valuable peppermint crop. Much of the mint acreage in Indiana may eventually be devoted to spearmint.

The spearmints, especially scotch spearmint, are frequently severely defoliated by a disease that is identified as *Septoria* leafspot. This disease is more severe in second-year or older plantings and is most damaging in rank stands. The symptoms include the initiation of small, dark circular spots or irregular patches on the leaf surfaces. These lesions gradually become white to gray-white centrally bordered by a deeper brown to black zone (fig. 1). Small, black pycnidia are produced within the lesions.

Little was known concerning the identity of the *Septoria* sp. causing this disease. Davis (1) reported *S. menthicola* Sacc. and Let. as causing a leafspot on *Mentha arvensis* L. in Wisconsin. Hemmi and Kurata (2) studied a similar disease in Japan and considered the pathogen to be *S. menthae* (Thum.) Oud.

The present studies were made to identify the causal organism of the leafspot disease of scotch spearmint in northern Indiana.

Methods and Procedures

Isolations of the causal organism were made directly from diseased leaf tissues by surface sterilization with sodium hypochlorite (1%) and incubation on potato dextrose agar (PDA). Spore suspensions for studies of spore germination were prepared either directly from diseased host tissues or from cultures grown on PDA. Measurements were made of representative spore samples and the number of septations recorded.

The effect of temperature on spore germination was determined. Spore suspensions from freshly isolated cultures were placed on water agar and incubated. Three plates were prepared for each temperature treatment and observations were made at 12 hour intervals for 72 hours. The temperature ranges used were 4° C. to 36° C. in increments of 4° C.

Results

Table 1 shows the spore size and number of septations observed in this investigation and those reported from other sources. *S. menthae* and *S. menthicola* differ mainly in spore size and number of septations, but septa-

[1] Contribution of Purdue University, Agriculture Experiment Station. Journal paper 1535.

Fig. 1. Foliar symptoms of *Septoria* leafspot on scotch spearmint *Mentha cardiaca* L.

tions are frequently not observed in spores from young cultures although the spores appear mature.

Table 2 shows the rather broad temperature range at which spores germinate. After 48 hrs., germination was nearly complete at the range from 12° C. to 32° C. The optimum was much more limited when the time was reduced to 16 to 24 hrs.

Discussion

The disease symptoms and morphology of the pathogen indicate that *Septoria menthae* is the cause of the leafspot of spearmint in Indiana. *S. menthae* has not been reported previously in the United States but it is apparently widespread in Europe and Asia. Earlier investigators made

TABLE 1. Comparison of the measurements of pycnospores of *S. menthae* and *S. menthicola* given by different authors.

Source	S. menthae			S. menthicola		
	Length μ	Width μ	septa	Length μ	Width μ	septa
Allescher(a)	58	1.0–2.0	0	30–40	1.0	0
Davis				18–33	1.0–1.5	
Hemmi	19.2–64	1.4–2.7	1–5			
Lind	35.0–48	1.0	3			
Saccardo	58	1.0–2.0	0	30–40	1.0	0
Sawada	25-64	1.5–2.5	1–3			
Writers-PDA	22.0–52.0	1.5–2.0	0–5			
Mint	24.0–58.5	1.5–2.0	0–5			

(a) From Hemmi, T. and S. Kurata (see ref. 2.)

TABLE 2. Germination of pycnospores of *S. menthae* at different temperatures.

Temp./Time	12	16	20	24	48	72
4° C				0	0	0
8°				0	0	66
12°				0	87	99
16°	0	0	6	25	97	99
20°	11	51	75	94	99	
24°	14	65	83	91	100	
28°	24	80	91	94	100	
32°	12	72	84	93	98	
36°				0	0	0

little attempt to accurately identify the host species. The marked differences in symptoms induced by these two pathogens may be a means of separating the two species.

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Some Algae of the St. Meinrad Area

Clarence Thomas, St. Meinrad College

The collections, from which the accompanying list of algae was compiled, were made between September, 1958, and September, 1959. All the algae were collected from within a radius of two miles of St. Meinrad Archabbey. This region includes sections of Spencer County which is located west of the Anderson River, and Perry County which is located east of the Anderson River; P or S after a species name indicates in which county, or counties, the species was found. All of the species are new reports for the counties cited; it seems that the only previously reported alga for either county is *Chara sejuncta*, found by Charles C. Deam in an artificial lake at Lincoln City in 1916 (1). The species marked by an asterisk are new reports for the state.

St. Meinrad is in the Mansfield sandstone belt, and outcroppings of sandstone on the sides of hills and the banks of streams abound. When these are kept moist by water seepage from the ground or spray from small waterfalls they provide excellent habitats for semi-terrestrial algae; in dryer areas lichens are to be found on these outcroppings.

The elevation of the area ranges from 440 feet to 620 feet above sea level, with the average elevation being about 500 feet. The Ohio River is ten miles south of St. Meinrad, and one of its tributaries, the Anderson River, is three-quarters of a mile east of the Archabbey. The Anderson River itself is usually quite muddy and has a very poor algal flora; but the smaller seasonal spring streams flowing into it along its course form many small quiet pools, and these have a considerable variety of algae growing in them. These pools, together with the many roadside ditches, furnished the main sources for the collection.

There are four artificial lakes in the area from which collections were taken. Two of these are about twenty-five years old and have established algal floras; the other two lakes are only about five years old, and although they show occasional "blooms" of one or more species they haven't the variety of species which the two older lakes show.

The writer wishes to extend special thanks to Father Fabian Frieders, O.S.B., under whose direction this work was made possible and accomplished, for his many helpful suggestions and for his interest in the project. The writer is also indebted to Mr. W. A. Daily for his suggestions, the use of unpublished keys on the Myxophytes, and his kindness in verifying some determinations.

All specimens collected for this study are deposited in the Henrietta Herbarium, of the Biology Department of St. Meinrad College, at St. Meinrad, Indiana.

Chlorophyta

Ankistrodesmus falcatus (Corda) Ralfs.....S
Chaetophora elegans (Roth) C. A. Agardh.....P
Chaetophora pisiformis (Roth) C. A. Agardh.....P
**Characium angustatum* A. Braun.....P

Chlamydomonas globosa Snow....P
Chlorella vulgaris Beijerinck....S
Cladophora crispata (Roth) Kuetzing....S
Cladophora glomerata (Linnaeus) Kuetzing....S
Closterium acerosum (Schrank) Ehrenberg....P
Closterium didytomocum Ralfs....S
**Closterium turgidum* Ehrenberg....S
Coelastrum microporum Nageli....P, S
Coleochaete irregularis Pringsheim....P
Coleochaete soluta (Brebisson) Pringsheim....S
Cosmarium supraspesiosum Wolle....P
Desmidium swartzii C. A. Agardh....P
Draparnaldia plumosa (Vaucher) C. A. Agardh....P
Eudorina elegans Ehr....P
Hormidium klebsii G. M. Smith....P
Hyalotheca mucosa (Mertens) Ehr....S
**Micrasterias rotata* (Greville) Ralfs....S
Microthamnion strictissimum Rabenhorst....P
**Nannochloris bacillaris* Nauman....S
Nephrocytium Agardhianum Nageli....S
Oöcystis borgei Snow....S
**Palmella miniata* Leiblein....P
**Palmellococcus protothecoides* (Kruger) Chodat....S
Pediastrum simplex Meyer var. *duodenarium* (Bailey) Rabenhorst....S
Pithophora oedogonia (Montagne) Wittrock....S
Protococcus viridis C. A. Agardh....S
**Protosiphon botryoides* Klebs....S
Rhizoclonium fontanum Kuetzing....P, S
Rhizoclonium hieroglyphicum (Agardh) Kuetzing....S
Scenedesmus bijuga (Turpin) Lagarheim....S
Scenedesmus dimorphus (Turpin) Kuetzing....S
Scenedesmus opoliensis P. Richter....S
Scenedesmus quadricauda (Turpin) Brebisson....S
Sphaerocystis schoeteri (Chodat)....S
Stigeoclonium stagnatile (Hazen) Collins....S, P
Stigeoclonium tenue (Agardh) Kuetzing....S
**Trebouxia cladoniae* (Chodat) G. M. Smith....S
**Treubaria crassispina* G. M. Smith....P
Trochiscia reticularis (Reinsch) Hansgirg....S
Ulothrix tenerrima Kuetzing....S
Ulothrix variabilis Kuetzing....S
Ulothrix zonata (Weber & Mohr) Kuetzing....P, S
Zygogonium ericetorum Kuetzing....S

Euglenophyta

Euglena clongata Schewiakoff....S
Trachelmonas hispida (Perty) Stein....S

Chrysophyta (Bacillariophyceae)

Fragilaria capucina Desmaziers....S
**Gyrosigma Spencerii* (W. Smith) Cleve....P
**Navicula seminulum* Grunow....S
Pinnularia divergens Wm. Smith....P
Rhoicosphenia curvata (Kuetzing) Grunow....S
Stauroneis anceps Ehr....P
**Synedra capitata* Ehr....P
Synedra ulna (Nitzsch) Ehr....S
Tabellaria fenestrata (Lyngbye) Kuetzing....P

Pyrrophyta

Ceratium hirundinella (Mueller) Schrank.....P, S

Cyanophyta

Amphithrix janthina (Montagne) Bornet & Flahault.....S
Anabaena variabilis Kuetzing.....P, S
Anacystis incerta (Lemmermann) Drouet & Daily.....S
Lyngbya aeruginco-coerulea (Kuetzing) Gomont.....P
Lyngbya aestuarii (Mertens) Liebmann.....S
Lyngbya putealis Montagne.....S
Oscillatoria Agardhii Gomont.....S, P
Oscillatoria curviceps C. A. Agardh.....S
Oscillatoria formosa Bory.....S
Oscillatoria geminata Meneghini.....P, S
Oscillatoria grunowiana Gomont var. articulata (Gardner) Drouet.....S
Oscillatoria irrigua (Kuetzing) Gomont.....S
Oscillatoria princeps Vaucher.....P, S
Oscillatoria sancta (Kuetzing) Gomont.....S
Oscillatoria tenuis C. A. Agardh.....S
Oscillatoria tennis C. A. Agardh var. natans Gomont.....S
Phormidium ambiguum Gomont.....S
Phormidium favosum (Bory) Gomont.....S

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CHEMISTRY

Chairman: FRANK WELCHER, Indiana University
HOWARD BURKETT, DePauw University, was elected chairman for 1960

ABSTRACTS

Isolation and Characterization of a New Peptide Antibiotic. E. B. HERR, JR., M. E. HANEY, G. E. PITTENGER and C. E. HIGGENS, The Lilly Research Laboratories.—Many soil samples are examined in the search for new antibiotics. Recently, in such a screen, a new species of *Streptomyces* was isolated and named *Streptomyces capreolus*. This organism produces a peptide antibiotic with marked anti-tuberculosis activity. The active peptide is produced when the culture is grown on a medium of sugars, peptone, and inorganic salts. The antibiotic is a strongly basic peptide and is isolated as the tetrahydrochloride salt by adsorption on charcoal followed by fractional precipitation. Elemental analyses suggest an emperical formula of $C_{24}H_{51}O_{10}N_{13}Cl_4$. Electrometric titration indicates an approximate molecular weight of 885. A total hydrolysis of the antibiotic (5.7N HCl, 100°C., 24 hrs.) releases the neutral amino acids, alanine, serine, and glycine. These amino acids have been identified qualitatively by their chromatographic behavior. Three basic amino acids also have been identified following total hydrolysis. One was isolated, crystallized, and identified as $\alpha\beta$ diaminopropionic acid. A second basic amino acid appears to be ornithine or an analogous compound as determined by the chromotographic behavior of the free amino acid and the dinitrophenyl derivative. The third basic amino acid has been crystallized and does not appear to be a commonly known amino acid.

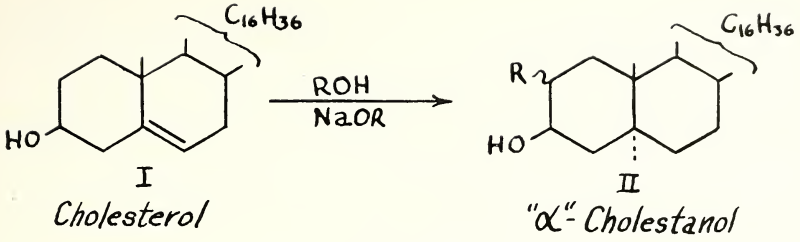
In vivo testing in mice shows this antibiotic to be highly effective against TB organisms. In addition to the anti-TB activity, the antibiotic has a low order of gram-negative activity. The compound is much less toxic than other anti-TB agents. The biological activity and some of the structural aspects of the antibiotic will be discussed.

Anomalous Meerwein-Ponndorf Reduction in Steroids . . . "α" Cholestanol. QUENTIN R. PETERSEN, Wabash College.—Cholesterol (I), when refluxed with strong base for a three hour period is completely modified, no unchanged cholesterol remaining.

Cholesterol (I), when refluxed with strong base for a three hour period is completely modified, no unchanged cholesterol remaining.

The oily product of this reaction has been examined exhaustively by chromatographic techniques.

Six pure compounds have been obtained from the reaction mixture, four of which contain no remaining unsaturation. The product obtained in highest yield (20%) appears to be an alkylated cholestanol (II, "α" cholestanol). Thus, the unique reaction shown below must have occurred.



The implications of the reduction of double bonds under Meerwein-Ponndorf conditions are discussed and some possible mechanistic paths leading to the observed products are suggested.

Ortho Substituted 2-Phenylquinolines. C. E. KASLOW and HENRY MOE, Indiana University.—A series of 2-(o-halophenyl)quinolines (X = F, Cl, or Br) were prepared. In one series, an attempt was made to introduce bromine in position-3 in through the usage of a 2-aryl-4-hydroxyquinoline. However when chlorine or bromine was introduced in place of the hydroxy group, hydrogenolysis was not selective enough to remove only the halogen in position-4. o-Halo-acetophenones and -propiophenones were prepared and subjected to the Pfitzinger reaction to give 2-(o-halophenyl)cinchoninic acids and 2-(o-halophenyl)-3-methylcinchoninic acids. These were decarboxylated to the 2-(o-halophenyl)quinolines and 2-(o-halophenyl)-3-methylquinolines. The o-haloacetophenones were converted to the corresponding phenacyl bromides and the latter to the phenacyl acetates which were, in turn, subjected to the Pfitzinger reaction. These 2-(o-halophenyl)-3-hydroxycinchoninic acids were also decarboxylated. The substituted quinolines were all converted to the methiodides. An attempt was made to carry out a resolution of some of the methiodides in which one might expect considerable hindrance to rotation but these were unsuccessful. A comparison of the ultraviolet spectra of the methiodides of the 2-(o-halophenyl)-quinolines and the 2-(o-halophenyl)-3-methylquinolines indicated that the aryl and quinoline rings could become coplanar. The synthesis of other quinoline compounds related to this work is described.

Inorganic Membrane Electrodes[1]

ROBERT B. FISCHER and MARVIN L. YATES, Indiana University

Several types of membranes have been studied and used as indicating electrodes. Foremost is the glass electrode for pH measurement. Other types include collodion membranes (2,5), membranes of clay minerals and ion exchange membranes (3,4). In addition, inorganic ionic precipitates have been formed into membranes. An earlier report from this laboratory (1) described the preparation of such membranes using a paraffin binder and their application as potentiometric indicating electrodes. The potentiometric data were interpreted on the basis that the surfaces of the inorganic particles assume an electrical charge, determined jointly by the precipitate and the composition of the electrolyte solution in contact with it, thereby permitting oppositely charged counter ions to pass through the membrane. This type of membrane can be useful as an indicating electrode, although irreproducibility and incomplete selectivity are serious limitations, and also as a means of measuring the surface electrical properties of the material of which the membrane is composed.

The purpose of the present report is to describe results of experiments on the "electrical rectifier" properties of the membranes and on radiotracer experiments designed to ascertain more specifically the ion transport characteristics of the membranes.

Membranes As Rectifiers

The membranes should function as electrical rectifiers if they preferentially permit either cations or anions to pass, as prior data show (1). This phenomenon was investigated by a d-c conductance method. Deionized water was placed on one side of the membrane, which was sealed across the end of a glass tube, and an electrolyte solution on the other side. The passage of electrical current through the membrane must consist of the flow of ions through the membrane, and this ion flow must be predominately from the electrolyte side to the water side because the water side has relatively very few ions available for flow. The electrical conductance was measured first with the water side positive, so anions must pass through the membrane, and then with the same side negative, so cations must pass through. The ratio of the d-c conductances in the two directions of applied potential is a measure of the rectifier property of the membrane and thereby a measure of the membrane's preference to pass cations or anions.

It was found that a time factor was significant. The observed membrane conductance changed as the potential was continuously applied in either direction. Constant readings were not obtained in fifteen minutes and longer in some cases, with the current flow during measurement ranging from a few microamperes to several milliamperes. It was also found that, the longer the potential was left on in one direction, the longer

1. Contribution 929, Chemistry Department, Indiana University. Work supported by the U. S. Atomic Energy Commission under contract AT(11-1)-497.

it took to approach an approximately constant conductance in the opposite direction. Repeated short cycling of the applied potential did not improve the situation significantly. Therefore the magnitudes of the conductances and conductance ratios are not quantitatively meaningful, but the identification as to whether cations or anions are preferentially passed through the membrane is very definite.

Data of typical measurements on membranes of several compositions are listed in table 1.

TABLE 1. Rectifier Data on Membranes

Membrane	Test Electrolyte	Preference	Conductance Ratio for cations / for anions
$BaSO_4$ in paraffin	$BaCl_2$	anion	0.26
	Na_2SO_4	cation	1.40
Apatite[1] in paraffin	$CaCl_2$	anion	0.50
	Na_3PO_4	cation	1.35
	KCl	anion	0.88
Apatite[2]	$CaCl_2$	anion	0.57
	Na_3PO_4	cation	1.72
	KCl	anion	0.85
$Ni(H_2C_4H_6N_2O_2)_2$ in paraffin	$NiCl_2$	anion	0.87
	$H_2C_4H_6N_2O_2$	cation	1.4
$Fe_2O_3 \cdot xH_2O$ (air-dried) in paraffin	NH_4OH	cation	1.25
	$FeCl_3$	anion	0.63
Fe_2O_3 in paraffin	NH_4OH	cation	1.5
	$FeCl_3$	anion	0.8

1. Powdered dental enamel, chiefly calcium hydroxy phosphate.
2. A slab of dental enamel from a human tooth.

The preferences are the same as those found in the potentiometric measurements (1) except for those of $FeCl_3$ solutions with both types of Fe_2O_3 membranes. The general agreement substantiates the concept that each precipitate preferentially adsorbs as a primary layer whichever lattice ion is available in the test electrolyte and permits preferential passage of the oppositely charged counter ions.

The rectifier-type measurements are of interest for straight-forward analytical applications, because in a precipitation titration the medium should change from one causing cation preference to one causing anion preference, or vice versa, upon passing through the region of the equivalence point. The time factor, however, makes the method impractical for titrations, although these measurements are useful in providing information on the surface electrical properties of precipitates.

Radiotracer Experiments on the Membranes

Radiotracer experiments were undertaken to obtain direct verification of the concept of ion transport through membranes of barium sulfate in

paraffin. Several series of experiments were run, using active Ba-133 as $BaCl_2$ and active Cl-36 as NaCl. In each experiment the active solution was placed on one side of the membrane and deionized water was placed on the other side. Aliquots of the latter were subsequently withdrawn for counting.

In the first series of experiments, using $Ba^{133}Cl_2$ and making potential measurements simultaneously, it was found that essentially no active Ba^{++} was transported through the membrane, even after potential equilibrium was established. Upon subsequent soaking of both sides of each membrane in water, much more active Ba^{++} was desorbed from the side initially in contact with the active solution than from the other side. Therefore, it is concluded that $BaSO_4$ membranes in contact with $BaCl_2$ solution, pass very little or no barium ions, a conclusion in full agreement with the rectifier and potentiometric conclusions that anions are preferentially passed.

Several series of experiments with deionized water on one side of the membrane and a solution of $NaCl^{36}$ plus either $BaCl_2$ or Na_2SO_4 on the other side, revealed a somewhat greater passage of Cl^- when under the influence of Na_2SO_4 than when under the influence of $BaCl_2$. This observation appears at first to contradict the potentiometric and rectifier data, which indicated a cation preference with Na_2SO_4 and an anion preference with $BaCl_2$. It is felt, however, that all three types of observation can be combined into a single concept, as follows.

None of the potentiometric or rectifier-type data reveal a complete preference for either cation or anion transport. Thus the "pores" through the membrane, which certainly must exist for any ion passage to occur, must be sufficiently large so that the electrical charges upon the surfaces of the particles within the membrane do not exert influence throughout the entire cross-section of the pore. As a group of ions enters a pore, that ion which forms the tightly-held primary adsorption layer is held back most tightly, that ion which forms the less tightly-held counter ion layer is held back slightly, and other ions are retarded only by such factors as ion mobility and are not influenced by the walls of the pore at all. Thus, with a $BaSO_4$ membrane and an electrolyte of Ba^{++} Cl^- and Na^+ ions, the Ba^{++} ion is held back most tightly, oppositely charged Cl^- ion is held back somewhat, and Na^+ ion is not held back at all by the $BaSO_4$ surfaces along the pores. Alternatively, with an electrolyte consisting of Na^+, $SO_4=$ and Cl^- ions, the $SO_4=$ ion is held back most tightly, the oppositely charged Na^+ ion somewhat, and the Cl^- ion not at all. This concept of the mechanism is consistent with the radiotracer data, in that Ba^{++} results in Cl^{36} ions being held back somewhat while $SO_4=$ results in no specific retardation of Cl^{36} ions. The concept is also consistent with the potentiometric and rectifier-type data, in that Ba^{++} causes a preference for anion passage (the ion held back most tightly is a cation) while $SO_4=$ causes a preference for cation passage (the ion held back most tightly is an anion).

If this concept is correct, a membrane should retain Cl^{36} more tenaciously after treatment with Ba^{++} solution than after treatment with $SO_4=$ solution, even though the latter passes more Cl^{36} than the former. Such was invariably found to be the case. Therefore it is now felt that this visualization of the mechanism whereby ions pass through the membranes provides a valid means of correlating the three types of measurement—

potentiometric, rectifier-type and radiotracer. It is further felt that the concept is fully consistent with zeta potential measurements upon similar materials and with generally accepted concepts of adsorption of ions upon the surfaces of ionic precipitates.

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The Ultraviolet Spectra of Phloroglucinol and Its Ethers

HOWARD BURKETT and RICHARD MURPHY, DePauw University

The spectrum of phloroglucinol and that of its ether, 1,3,5-trimethoxybenzene, are reported to be identical in neutral (1,2,3), in weak acid (1,3) and in concentrated sulfuric acid (2) solutions. In connection with a study of the mechanism of the acid-catalyzed decarbonylation of 2,4,6-trimethoxybenzaldehyde it became necessary to learn whether or not 1,3,5-trimethozybenzene was the only initial product of the reaction. The 1,3,5-trimethozybenzene had been identified by isolation but the yield was not quantitative. A spectrographic method which could be applied directly to the reaction mixture seemed to be the most promising method to give a definitive answer. Hence, in spite of negative reports in the literature, an investigation was undertaken to discover acid conditions in which the spectrum of 1,3,5-trimethoxybenzene would serve to distinguish it from other likely products.

Initially, only phloroglucinol and 1,3,5-trimethoxybenzene were used. In 0-42% perchloric acid the spectra of the two compounds are the same. The only absorption maximum is a very weak one at *ca.* 265mμ. for each. This is consistent with the previous reports for the spectra in neutral and weak acid solutions. In 48.8%, 53.8% and 55.0% perchloric acid the spectra are different (Fig. 1). In 55.0% perchloric acid 1,3,5-trimethoxybenzene has absorption maxima at 252mμ. ($\epsilon = 24 \times 10^3$) and at 346 m$\mu$. ($\epsilon = 14 \times 10^3$). Phloroglucinol in the same acid has maxima at 242 mμ. ($\epsilon = 13 \times 10^3$) and at 342 m$\mu$. ($\epsilon = 9 \times 10^3$). The positions of the maximum absorption are the same in the lower concentrations of acid but the absorption is less intense. The absorption bands at the higher wavelengths are very broad and the maxima are only slightly different; hence, they are not useful for identification. The absorption bands at the lower wavelengths are quite sharp and sufficiently separated to be distinctive.

Since the monomethyl ether and dimethyl ether of phloroglucinol are also plausible products of the decarbonylation reaction, it was necessary to study their spectra. In 55.0% perchloric acid the results in the 340-350 mμ. range were intermediate between those for phloroglucinol and 1,3,5-trimethoxybenzene and were useless for identification. At the lower wavelengths the maxima were at 245 mμ ($\epsilon = 17 \times 10^3$) for the dimethyl ether and at 244 mμ. ($\epsilon = 15 \times 10^3$) for the monoethyl ether. In 48-55% perchloric acid 1,3,5-trimethoxybenzene can easily be distinguished from phloroglucinol and its monomethyl and dimethyl ethers.

In perchloric acid significantly above 55% concentration the spectra of phloroglucinol and 1,3,5-trimethoxybenzene were identical. In 70% perchloric acid, even working rapidly at *ca.* 9° C., the spectra of the two compounds were the same ($\lambda_{max.} = 242$ mμ.; $\epsilon = 15 \times 10^3$). For 1,3,5-trimethoxybenzene in 60% perchloric acid under the same conditions the absorption maximum was first seen at 245-248 mμ. and rapidly changed to 242mμ. The position of the maximum is that expected for phloroglucinol. That it is actually due to phloroglucinol is indicated by the following. Heating 1,3,5-trimethoxybenzene in 55% perchloric acid at 70° for

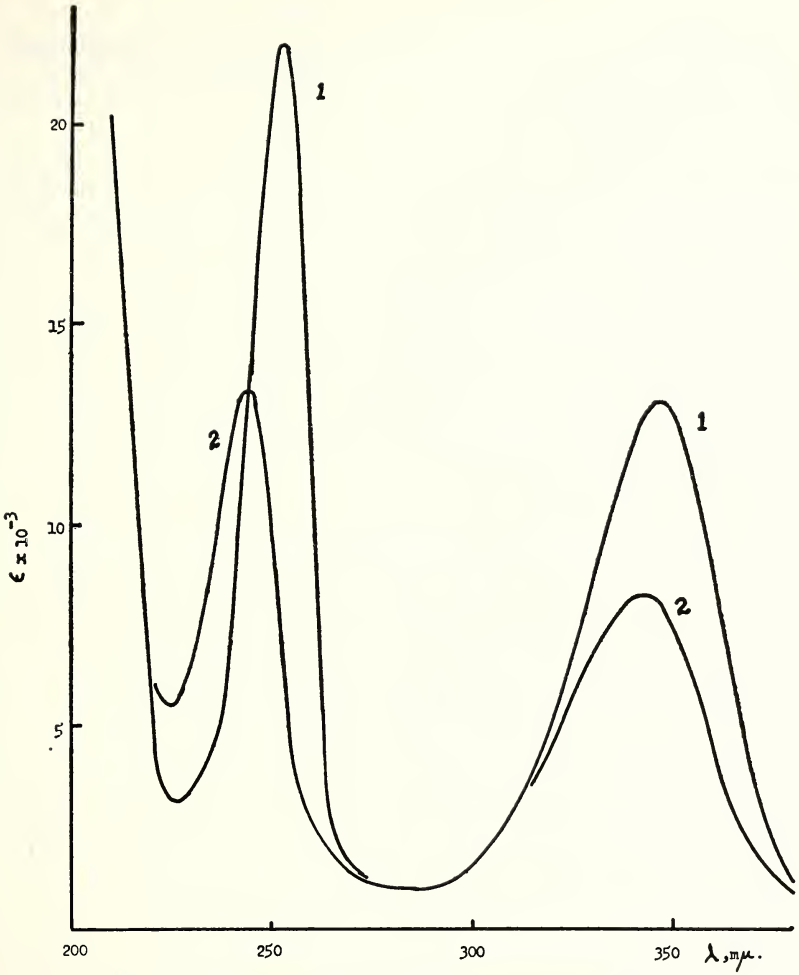

Fig. 1. Ultraviolet Spectra of (1) 1,3,5-Trimethoxybenzene and (2) Phloroglucinol in 53.8% Perchloric Acid.

twenty minutes or allowing it to stand for over twelve hours at room temperature caused the original spectrum to change to one identical with that of phloroglucinol in the same medium. The same change occurred, but more slowly, in acids of lower concentration. Hence, 1,3,5-trimethoxybenzene cannot be identified in perchloric acid solutions significantly above 55% because hydrolysis to phloroglucinol occurs too rapidly.

The nature and identity of the spectra ($\lambda_{max.} = 240$; $\epsilon = 10 \times 10^3$) for phloroglucinol and its trimethyl ether in 98% sulfuric acid reported by Valyasko and Voroshin (2) indicate that their results were also due to rapid hydrolysis of the ether to the unsubstituted parent compound.

Methods and Equipment

The phloroglucinol was a carefully purified and dried commercial material. The ethers were prepared by published methods (5).

The ultraviolet spectra were obtained with a Beckmann DU instrument.

The concentrations of the acid solutions were determined by titrating weighed samples with standard alkali. The solutions of the compounds were made in 25 ml. volumetric flasks using fractional milligram samples.

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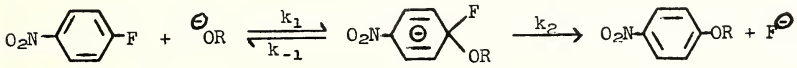
Reactivity of Perfluoroalkyl Groups and of Halogen in (Perfluoroalkyl) Halobenzenes

E. T. McBee, L. W. Frost, M. R. Frederick and O. R. Pierce,
Purdue University

In analogy to the superior reactivity of vinylic fluorides over other vinylic halides toward nucleophilic reagents, activated aromatic fluorine compounds have been known for some time to be considerably more reactive than the corresponding chlorides, bromides or iodides when exposed to certain nucleophiles. This was demonstrated conclusively by Bevan[1], who found that the reactivities of the *p*-nitrohalobenzenes toward alkoxide ion at 90.8° C corresponded to the ratios F : Cl : Br : I = 3,100 : 13.6 : 11.8 : 1, the fluoride being by far the most reactive. This is explained by a one-step mechanism alternate to the established S_N2 type mechanism, whereby the formation of a discrete intermediate is the rate-determining step.

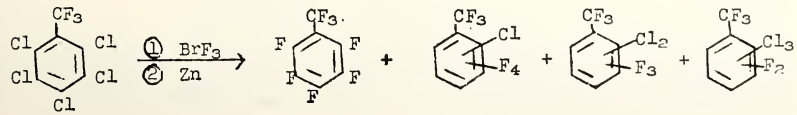


$$k_2 \gg k_{-1}$$

The considerable strength of the carbon-fluorine bond is now of relatively little importance, whereas the high electronegativity of fluorine, rendering the adjacent carbon atom positive and subject to nucleophilic attack, becomes the dominant factor. Although the reactivity sequence can be changed to ArBr > ArCl > ArF, by modifying the reaction conditions in order to increase the extent to which the carbon-halogen bond is broken in the transition state[2], under normal conditions the superior reactivity of the fluorides prevails.

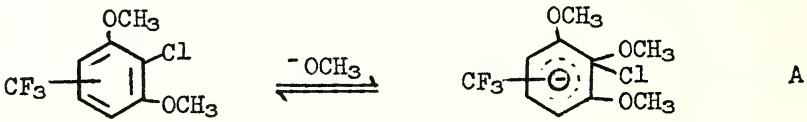
This high reactivity of activated aromatic fluorides toward nucleophiles is also encountered in polyfluorobenzenes. Thus, hexafluorobenzene very readily undergoes nucleophilic displacement[3,4,5], yielding, for example, pentafluorophenol, dihydroxytetrafluorobenzene and the corresponding ethers[4,5]. Apparently the activating atoms do not cancel each other out.

The question arises, how does a mixed halobenzene behave when activated by a haloalkyl side chain, and are there specific reactions for both ring and side chain halogens? Interesting results were obtained upon hydrolysis with methanolic base of the chlorotetrafluoro- and the dichlorotrifluoro(trifluoromethyl)benzenes, obtained by the method of McBee, Lindgren and Ligett[3] after fluorination of pentachloro-(trifluoromethyl)-benzene with bromine trifluoride and subsequent dehalogenation.



Treatment of the monochloride with an equimolar amount of base gave a chlorotrifluoro(trifluoromethyl)anisole. This product was very stable; subsequent photochlorination and exchange of chlorine for fluorine with antimony trifluoride resulted in exclusive substitution on the methoxy group.

More challenging, however, was the hydrolysis of the dichloride with excess base. Mainly dichlorotrimethoxy(trifluoromethyl)benzene, some starting material and a very small amount of methyl dichlorotrimethoxybenzoate were obtained. This complete retention of the chlorine atoms can be assumed to be caused by faster substitution of the fluorine atoms whereby one or more compounds are obtained which do not allow transition states of type A to be formed because of steric hindrance.



A

Table 1 lists rate coefficients obtained by Miller and Wrightson who subjected several trifluoromethylbenzene halides to nucleophilic displacement by ethoxide ion[6].

TABLE 1

Nucleophilic substitution of activated halobenzenes in 1.0 N sodium ethoxide[6]

Compound	Reacting	Non-reacting	$K_{(av.)}$ 1.mole^{-1} sec^{-1}
p-$CF_3C_6H_4F$	F	CF_3	4.44 x 10^{-3}
p-$CF_3C_6H_4Cl$	Cl	CF_3	5.83 x 10^{-6}
m-$CF_3C_6H_4F$	F	CF_3	1.08 x 10^{-4}
m-$CF_3C_6H_4Cl$	Cl	CF_3	5.83 x 10^{-7}
o-ClC_6H_4F	F	Cl	8.06 x 10^{-5}

It is unfortunate that the value for *o*-fluoro(trifluoromethyl)benzene is not known, since it is very possible that substitution of fluorine ortho to the bulky trifluoromethyl group meets with considerable steric hindrance, rendering the rate coefficient smaller than for *p*-chloro(trifluoromethyl)benzene. Should this be found true, our results would place the chlorine atoms in the *ortho* positions.

If, however, this should not be the case, the values show that chlorine would react slower in all three positions and thus could be situated anywhere in the ring. Unfortunately the presence of isomers could not be established at the time this research was performed. Nevertheless, the results are interesting because of the probability that forces participate in these reactions which are stronger than the *ortho-para*-directing influence of the trifluoromethyl group, known for its inductive and resonance polar effects. The reactions will be further investigated.

It was shown that basic hydrolysis affects the trifluoromethyl group only slightly. A different picture is obtained with acid hydrolysis; the ring halogens are not attacked whereas the trifluoromethyl group is con-

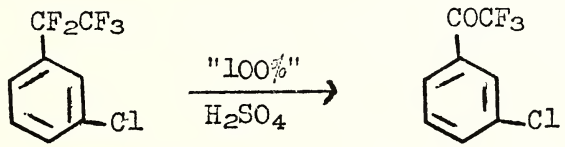
verted to a carboxyl function. This was demonstrated by Wertyporoch who prepared various chlorobenzoic acids from the corresponding trifluoromethylbenzene chlorides with 60-80% sulfuric acid[7].

Bis-(trifluoromethyl)benzenes[8] and their chloro compounds[9] can also be hydrolyzed, but concentrated sulfuric acid is required.

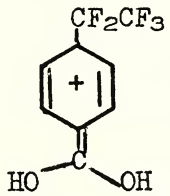
Bis-(pentafluoroethyl)benzenes and their chloro compounds do not react[9].

When extending these reactions to compounds with one fluoromethyl group and one larger side chain, surprising results were obtained. 4-(Trifluoromethyl)pentafluoroethylbenzene and 4-trifluoromethyl)heptafluoro-*iso*propylbenzene were hydrolyzed to 4-(pentafluoroethyl)- and 4-(heptafluoro*iso*propyl)benzoic acid, respectively. As before, the longer side chain was not attacked.

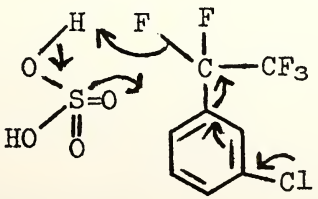
That the longer side chain is not unreactive, however, because of e.g. steric hindrance, can readily be seen from the fact that 3-chloro(pentafluoroethyl)benzene was hydrolyzed to 3-chloro(trifluoroacetyl)benzene.



It can be argued that with the compounds having mixed side chains, the trifluoromethyl group is attacked first because of steric hindrance of the ∝-carbon in the pentafluoroethyl side chain. Protonation of the ensuing carboxyl group would withdraw electrons from the pentafluoroethyl substituent, rendering it inactive.



However, no explanation can be given for the total inactivity of the bis-pentafluoroethyl benzenes and the relative ease with which 3-chloro-(pentafluoroethyl)benzene is hydrolyzed, under the *m*-chlorine atom activates the carbon-fluorine bond sufficiently to permit hydrolysis.



Reactions of this very interesting nature will be further investigated.

Experimental

Chlorotrifluoro(trifluoromethyl) anisole. A solution of 54 g. of potassium hydroxide in 300 ml. of methanol was added slowly, with stirring, to 203 g. of chlorotetrafluoro(trifluoromethyl)benzene. Stirring was continued until the mixture cooled to room temperature. It was poured into one liter of water. The organic layer was separated, washed with water, dried and rectified to give 17 g. of starting material and 100 g. (51% yield) of chlorotrifluoro(trifluoromethyl) anisole, having the following properties: bp. 63/6 mm, mp. –42 to –44, n_D^{25} 1.4360, d_4^{25} 1.595. *Anal.* Calc. for $C_8H_3OCl\ F_6$: Cl, 13.4; F, 43.2. Found: Cl, 13.8; F, 42.7.

A small amount of higher-boiling residue remained, indicating the presence of polymethoxy compounds.

Chlorination of chlorotrifluoro(trifluoromethyl) anisole. Chlorotrifluoro(trifluoromethyl) anisole (97 g.) was illuminated by three 200-watt incandescent lamps while chlorine was bubbled through it for 30 hrs. at a temperature below 50°. Air was blown through the liquid to remove dissolved gases, leaving 123 g. of a pale yellow liquid. *Anal.* Calc. for 22 mol % $C_8O\ Cl_4F_6$ + 78 mol % $C_8HOCl_3F_6$: Cl, 33.6; F, 33.4. Found: Cl, 33.6; F, 33.6.

Chlorotrifluoro(trifluoromethoxy)(trifluoromethyl)benzene. The product from the chlorination of chlorotrifluoro(trifluoromethyl) anisole (412 g.) was refluxed for 1.5 hrs. with 250 g. of antimony (III) fluoride and 74 g. of antimony (V) chloride. The organic product was decanted from the antimony salts, washed with hydrochloric acid and water, dried and rectified to give 104 g. of a fraction boiling at 135°, 115 g. of crude chlorotrifluoro(trifluoromethoxy) (trifluoromethyl) benzene (bp. 146-150), and 67 g. of residue. A purified sample of chlorotrifluoro(trifluoromethoxy)-(trifluoromethyl)benzene was found to have the following properties: bp. 150, mp. –56 to –57, n_D^{25} 1.3875, d_4^{25} 1.710. *Anal.* Calc. for $C_8OCl\ F_9$: Cl, 11.2; F. 53.7; MW, 318. Found: Cl, 13.2; F, 54.9; MW 316.

The fraction boiling at 135° was found to contain 15.9% Cl and 51.0% F. This boiling point and composition suggest that the material may be chlorotrifluoro(trifluoromethyl)benzene or chlorotetrafluoro(trifluoromethyl)benzene.

Dichlorotrifluoro(trifluoromethyl)benzene and methanolic potassium hydroxide. Potassium hydroxide (300 g.) was dissolved in a small amount of water, and methanol was added to make 500 ml. of solution. This solution was added, with stirring, to 404 g. of dichlorotrifluoro(trifluoromethyl)benzene, at such a rate that a steady reflux was maintained. After the addition was complete, the mixture was refluxed for another three hrs. The organic layer was separated, washed with water, dried and rectified to give 50 g. of dichlorotrifluoro(trifluoromethyl)benzene and 183 g. (42% yield) of dichlorotrimethoxy(trifluoromethyl)benzene, bp. 106-117/7 mm. (*Anal.* Calc. for $C_{10}H_9O_3Cl_2F_3$: Cl, 23.3; F, 18.7. Found: Cl, 23.7; F, 16.9), and 38 g. of a semi-solid fraction, bp. 117-127/7 mm. Recrystallization of the last fraction from ethanol-water gave 6 g. of crystalline methyl dichlorotrimethoxybenzoate. *Anal.* Calc. for $C_{11}H_{12}O_5Cl_2$: Cl. 24.1; F, 0.0. Found: Cl, 23.3; F. 0.0.

4-(Pentafluoroethyl)benzoic acid. Fifty grams of 4-(trifluoromethyl)-(pentafluoroethyl)benzene[3] was refluxed with 250 ml. of concentrated

sulfuric acid[1] for 24 hours. When cool the mixture was poured on to ice, the solid acid removed by filtration, and washed with water; m.p. 155-6° (after one recrystallization from ethanol); b.p. 242-3° (748 mm.).

Anal. Calcd. for $C_9H_5F_5O_2$: F, 39.1; M. W., 240. Found: F, 39.3; M. W., 233.

4-(Heptafluoroisopropyl)benzoic acid. In a similar manner 4-(trifluoromethyl)-(heptafluoro*iso*propyl)benzene[10] was hydrolyzed to 4-(heptofluoro*iso*propyl)benzoic acid; m.p. 102.5-103.5; b.p. 246-246.5 (748 mm.). *Anal.* Calcd. for $C_{10}H_5F_7O_2$: F, 45.9; M. W., 290. Found: F, 45.7; M. W., 286.

3-Chloro-(trifluoroacetyl)benzene. Fifty grams (0.22 mole) of 3-chloro-(pentafluoroethyl)benzene and 300 g. of concentrated sulfuric acid (95.5%, sp. gr. 1.84) were heated at a temperature sufficient to reflux the organic compound vigorously. After two hours hydrogen fluoride was being evolved. The experiment was stopped at the end of 15 hours and when cool the mixture was poured on to ice. The organic oil, the bottom layer, was separated, washed with water and dried. Distillation gave 29 g. (0.14 mole) of 3-chloro(trifluoroacetyl)benzene[8], 64%; b.p. 182.5-183° (751 mm.); n_D^{25} 1.4250; d_4^{25} 1.406. *Anal.* Calcd. for $C_8H_4ClF_3O$: Cl, 17.0; F, 27.3; M. W., 208. Found: Cl. 17.4; F. 27.6; M. W., 203.

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1. In reference to previous work[9] it has been pointed out by Scheurer and Le Fave[8] that 60-80% sulfuric acid is not suitable for the hydrolysis of the bis(trifluoromethyl) benzenes. On checking the original work of McBee and Fredrick[9] it has been found that concentrated sulfuric acid (95.5%) was the reagent actually used and that the 60-80% figure got into the paper by error in abstracting the thesis.

ENTOMOLOGY

Chairman: JOHN DAVIS, Purdue University

R. E. NISWANDER, Manchester College, was elected chairman for 1960

ABSTRACTS

The Life History of *Pemphredon lethifer lethifer* (Shuckard) (Hymenoptera, Sphecidae). LELAND CHANDLER, Purdue University, NANCY WORK, West Lafayette High School, and FRED SHEWMAN, Akron High School.—*Pemphredon lethifer lethifer* (Shuckard) is an adventive wasp only recently recognized in North America. The species nests in pithy-stemmed plants, especially raspberry, sumac, elderberry and rose. The cells are provisioned with aphids of several species, but only one species is used per cell. The number of aphids per cell ranged from 40-80. The number of cells per nest ranged from 1-22. The egg is laid horizontally about one-fourth of the way from the bottom of the cell. The incubation period was about 28 hours. The length of the larval feeding period was not determined although it was approximately 7-10 days. The prepupal period ranged from 1-3 days, the pupal period, 5-8 days. There are a number of generations per year, the species overwintering as a prepupa. The species is parasitized by a cuckoo wasp, *Omalus auratus* (L.), which is also an introduced species. An ichneumon wasp, *Perithous pleuralis* Cresson, is an external prepupal parasite, the life history also being recorded in this study. Fungi cause the death of the developing brood and spiders are important predators.

Protecting Cucumbers from Insects by the Use of Electric Light Traps. HOWARD O. DEAY, Purdue University, and JAMES G. HARTSOCK, U. S. Department of Agriculture.—Experiments were conducted at Lafayette, Indiana in the seasons of 1958 and 1959 to determine if cucumber plants in home vegetable gardens could be protected from striped and spotted cucumber beetles by the use of fan-type electric light traps. In spite of the fact that the rainfall in the two years was very different (1958 being especially wet and 1959 especially dry), the results obtained in the two years were very similar. A single trap equipped with three 15-watt Black Light lamps per plot protected the cucumbers in both years very effectively. Traps equipped with either one 15-watt Black Light lamp or with one 15-watt Black Light lamp plus one 15-watt green fluorescent lamp gave same protection but not as much as did the trap equipped with three 15-watt Black Light lamps.

Some New Permian Insects and Insect Localities. J. R. ZIMMERMAN, Indianapolis.—Sellards, Tillyard, and Carpenter have made extensive reports on Permian insects found near Elmo, Dickinson County, Kansas. All of the specimens were taken from but a single quarry. Carpenter has also reported three orders from several localities in Noble County, Oklahoma. Dr. Paul Tasch, University of Wichita, in studying fossil Conchostraca (clam shrimps) has found insect fragments from at least fourteen

localities distributed in every county from Dickinson County, Kansas, to Kay County, which is immediately north of Noble County, Oklahoma. The two Oklahoma insect horizons are stratigraphically above the insect beds in Kansas (Paul Tasch, personal communication). About 350 insect specimens have been found thus far by Tasch and his workers. Representatives of all but two Elmo orders have been definitely recognized. New species have been found in the extinct orders, Protorthoptera, Megasecoptera, Protelytroptera, and in the living orders, Odonata, Corrodentia, Homoptera, and Neuroptera.

Entomological Facilities and Services of the Indiana Farm Bureau Cooperative. WALTER WEBER, Indiana Farm Bureau.—The history and development of the Indiana Farm Bureau Cooperative were discussed. The various services were described. An extensive amount of informational material is distributed each year.

The Nesting Habits of *Osmia albiventris* Cresson (Hymenoptera, Megachilidae). LELAND CHANDLER, Purdue University. The nests of *Osmia albiventris* were found in nail holes and behind window casings of a poultry house and the species also utilized trap nest boards. Nests were kept under observation from June 1 (beginning of provisioning) to July 1 (last female died). Where a single, tubular cavity existed (e.g., nail hole, trap nest), the female constructed a series of linear cells made of chewed plant materials. The average size of the cells (outer dimensions) was 9 mm. in length and 6 mm. in width. They were obovate in shape and were placed in planes ranging from horizontal to vertical. Three to four cells made up a single series but each female constructed several series during her life span. The nests located behind window casings were compound, several females provisioning independent series of cells. The chewed plant materials were compacted tightly and formed a mass which could be removed intact from the site. The nest masses were rather complicated since they incorporated nests constructed over a period of several years and included cells of *Megachile* spp. as well as those of *Osmia*. Observations on provisioning, oviposition, development, predators, parasites and pollen-sources were completed. The larvae of the black carpet beetle, *Attagenus piceus*, were the primary predators.

Notes on Regulatory Entomology in Indiana, 1959. JOHN FAVINGER and FRANK MADINGER, Indiana Department of Conservation.—During 1959 the Division of Entomology initiated a reappraisal and reorientation—of regulatory projects within its province—aimed at improving, and facilitating, legal control of movement of exotic insect pests and plant diseases in Indiana. The changes resulting from this re-evaluation include a more intensive inspection and licensing of nursery dealers and agents and a change in survey procedures for exotic plant pests. Increased movement of nursery stock through interstate channels presents increasing opportunity for introduction of plant pests alien to Indiana agriculture. Therefore, examination and licensing of nursery stock handled by nursery dealers and agents has been given much emphasis and effort during 1959.

Exotic plant pest surveys were redesigned during 1959 to include (1) intensive *detection surveys*, for a given season, to indicate location of

incipient infestations; and (2) *delimitation surveys*, the following season, to determine population densities. During 1959 the *detection-type survey* for Japanese beetle (*Popilia japonica* Newman)—which was predicated upon the theory that common carriers (especially railroads) serve to introduce the pest—revealed 20 heretofore unknown locations of Japanese beetle. These locations were in or near: *Arcola, Beech Grove, Bolivar Crossing (Wabash Co.), Bourbon, Carbon (Clay Co.), Clarks Hill, Clarksville (Clark Co.), Columbus, Crawfordsville, Hamlet (Starke Co.), Hobart, Jamestown (Elkhart Co.), Kingsland (Wells Co.), Laketon, LaPorte, Montezuma, Peru, Pierceton, Roachdale, Seymour.* An important aspect of this type of survey is that these 20 locations represent 12 new county records, as well as significant infestations for the first time in that part of the state south of U. S. 40.

The Division has also devoted more time and interest to excluding the following exotic pests from Indiana: *European chafer (Amphimallon majalis)*, White-Fringed Beetle *(Graphognathus* sp), Soybean Cyst Nematode *(Heterodera glycines)*, Khapra beetle, *(Trogoderma granarium)*, Imported Fire Ant *(Solenopsis saevissima richteri)* and Gypsy Moth *(Porthetria dispar)*.

Aerial Application in Agriculture. RICHARD L. CUNNINGHAM, Aeronautics Commission of Indiana.—The beginning of aerial application goes back to 1919 when the U. S. Department of Agriculture aerially dusted fruit trees infested with caterpillars (larvae of the catalpa sphinx), which fed on the leaves. From that origin the practice has expanded to the point that aerial crop control work is now done on more than 200 different types of crops. One of every twelve acres under cultivation is treated from aircraft. Insect control has been, and still remains, the primary use of airplanes in agriculture, although it is far from the only one. The importance of insect control to the farmer can readily be seen when it is realized that losses caused by all insects add up to a staggering $4 billion each year despite the control measures now available. The major uses of the airplane in agriculture may be grouped into five rather broad classifications: (1) insect and plant control, (2) weed and brush control, (3) fertilization, (4) defoliation, and (5) seeding. In 1957, nearly three-fourths of all agricultural flying involved the control of insects and plant diseases.

The Effectiveness of Systemics when used in Different Ways. RICHARD CRUM, Purdue University.—A variety of techniques were demonstrated to show the effectiveness of systemic insecticides. The solutions were applied by hypodermic needle, sprinkler can, speed sprayer, and custom-made tree injection equipment. The materials used were di-syston, demeton, and phorate. Applications of these systemics were made to a variety of weeds, shrubs, and trees, demeton being the most efficient material used.

The Use of *Bacillus thuringiensis* Berliner for the Control of Cabbage Caterpillars. WILLIAM L. PARROTT, Purdue University. The bacterium, *Bacillus thuringiensis* Berliner, is now being formulated by several concerns and in preliminary tests has been effective against certain cater-

pillars. Field tests were conducted during the summer of 1959 at the Purdue University Agronomy Farm in Tippecanoe County to determine the effectiveness of this organism on the imported cabbage worm, *Pieris rapae* (L.), and the cabbage looper, *Trichoplusia ni* (Hbn.). *Bacillus thuringiensis* was applied as a spray to the cabbage plants by suspending the spore formulation in water. A wetting agent was added to insure an adequate coverage of the foliage. Applications were made at six, twelve and eighteen days intervals to determine the degree of control and the length of residual action. Population counts were made at six day intervals by examining the plants for the presence of the larvae of the two species. Results indicated that satisfactory control of the imported cabbage worm was obtained only by applications of *Bacillus thuringiensis* at six day intervals. At the rate tested (3 pounds of commercial formulation per acre), this bacterium was not effective in reducing the cabbage looper population. Tests on both early and late cabbage gave similar results.

Entomology and the Indiana Academy of Science

J. J. Davis, Purdue University

Entomology has always been a part of the Indiana Academy of Science and many nationally and internationally recognized entomologists have been members.

In the first proceedings published in 1891, we find a summary of papers presented to the Academy from 1885-1891. Of these, 34 referred to insects or related arthropods, presented by 11 men, as follows: P. S. Baker, one; W. S. Blatchley, six; C. H. Bollman, one on entomology and two on myriopods; R. F. Hight, one; G. C. Hubbard, two; O. P. Jenkins, one on arachnids and one on invertebrates; J. S. Kingsley, four or myriopods; Jerome McNeill, three on insects and one on myriopods; W. P. Shannon, one; F. M. Webster, nine; and A. J. Woolman, one.

Four entomologists have been presidents of the State Academy, as follows: W. S. Blatchley, 1903; E. B. Williamson, 1918 and 1919; J. J. Davis, 1931; and F. N. Wallace, 1940.

From the beginning until 1926 curators were named for Entomology, as well as other groups, such as Ornithology, Herpetology, and Mammalogy. So far as I know the Academy has never maintained or been responsible for collections or a museum and I do not know the functions of these curators or what they cared for. At any rate, F. M. Webster was listed as curator of Entomology from 1891 to 1895 and W. S. Blatchley from 1895 to 1926.

Previous to 1946, entomology was a part of the zoology section, but since an increasing number of the zoologists and papers in the section were entomologists' and entomological papers, the Academy provided a special section for entomology, beginning with 1946. The chairmen of the Entomology Section were as follows: G. E. Lehker, 1946; Arlo M. Vance, 1947; W. P. Allyn, 1948; Edw. Kintner, 1949; G. E. Gould, 1950; J. A. Clark, 1951; F. N. Young, 1952; M. Curtis Wilson, 1953; Paul T. Ulman, 1954; Donald Hamilton, 1955; Donald L. Schuder, 1956; H. O. Deay, 1957; John J. Favinger, 1958; and J. J. Davis, 1959.

It should be noted that for a number of years, entomologists met in special session on Saturday, the day following the main session of the Academy, to discuss their mutual problems of insect taxonomy and economy. These were discontinued in 1946 with the establishment of a section on entomology.

As stated, from the beginning of Indiana history to the present time insects and entomologists have played a significant role. In reports of travel, such as those published by the Indiana Historical Commission, we learn that early in the 19th century, travelers reported insects, such as army worm, as destroying crops; horseflies a serious annoyance to cattle; and many kinds, especially the mosquito, annoying to human beings. Ague, now known as malaria, and carried by the mosquito, was a common ailment, especially to newcomers.

There were many, 100 to 200 years back, who were ardent insect collectors and one of the first was Thomas Say of New Harmony, generally

referred to as the Father of American Entomology. Many amateur insect collectors made extensive insect collections, but unfortunately, for the most part, these have been lost or destroyed by museum pests. Purdue is the possessor of one such collection made by Constantine Troxler of Louisville, Ky. who collected Leptidoptera in northern Kentucky and southern Indiana from 1875-1900.

Then came the era of the modern amateur entomologist, including such persons as E. B. Williamson, whose collection is at the University of Michigan, W. S. Blatchley, whose collection is at Purdue University, J. Speed Rogers, whose collection is at the University of Michigan and A. C. Kinsey, whose collection is at Indiana University.

With the establishment of the land grant colleges and state agricultural experiment stations, the field of professional entomology was established, and with opportunities in entomology as a vocation increasing, courses were offered in the majority of state land grant colleges for training in the field. The field for trained entomologists was still further enlarged with the demand for insect control services some 25 years ago and the recognition of the need for consultant and service pest control operators.

Even so we owe much to the pioneers mostly those who we call amateurs, who studied insects as an avocation and depended on various vocations for their livelihood. They did much to promote the now large and important field of entomology.

From these facts, it will be seen that entomology and entomologists have played a major part in the activities and growth of the Indiana Academy of Science.

Our observations over the years, since I joined the Academy nearly forty .years ago, lead us to reflect on the purposes and objectives of the Academy. Perhaps, first of all we should recognize the fact that it brings together the scientific workers of the State in annual and semi-annual meetings to stimulate better acquaintance, maintain and establish friendships, provide incentives, and develop discussions of various interests and problems of mutual concern.

The Academy should act as a clearing house for scientific information by bringing together the scientific men and women of the State in order to exchange ideas and provide the stimulus of association.

Perhaps the main purpose is to stimulate interest in the scientific problems of the area, together with a stimulation for investigation and research in science in general.

As we study the hundreds of papers presented before the Academy, one fact predominates and that is that the early scientists were general scientists and were interested in many subjects. In more recent years, scientists have become more specialized and less generalized in their interests. In an Academy of Science perhaps we should think more in terms of general science, rather than confine our thinking and study to smaller groups of the sciences.

The Water Beetles[1] of a Temporary Pond in Southern Indiana

FRANK N. YOUNG, Indiana University

It is becoming increasingly difficult to find any natural situation in the Eastern United States which is unmodified by human activity. The whole region is, or is rapidly becoming, one great intermeshing complex of towns and cultivated lands in which only here and there so-called "wilderness areas" are preserved. Even the latter should eventually acquire a different fauna and flora if our general theories of habitat occupancy are correct. That is, in the case of aquatic situations, pond still completely surrounded by forest should be invaded by species from neighbouring ponds, ditches, and empoundments of the "artificial steppes" and the latter should acquire by chance migration some of the "woods pond" species.

It seems, however, that significant interchange of fauna is remarkably slow if it occurs at all either in aquatic or terrestrial habitats. The changes in the fauna of ruderal areas seems largely due to extension of the populations of species already existing in some minor habitats of an area into the artificial extensions of these habitats (1). Migrations into an area from outside seem to be largely restricted to highly modified areas such as cultivated fields although once established in such situations migrants may then establish interrelations with surrounding habitats. These aspects of habitat occupancy have been largely neglected in studying aquatic insects, but considerable evidence is accumulating in regard to some groups such as the grasshoppers and locusts where precise information is of great economic value.

One of the aquatic habitats which seems ideal for studies of population changes is the small, silt-bottomed temporary pond. Ponds of this type are now widely distributed over the Eastern United States. Most of them are man-made being either artificial stock ponds or the result of agricultural practices. Regardless of their origin, however, they now represent a characteristic type of aquatic situation over a wide area and support a rich invertebrate fauna. In permanent ponds, there is a definite succession of water beetle species from the first occupants of a newly formed pool to the species which occur only in situations which are many years old. This succession is not yet fully understood, but in temporary ponds it appears to begin anew each time the pond dries and refills. A temporary pond may thus present an annual succession similar to that which develops in permanent ponds over a period of years, and the study of such situations should allow further analysis of the factors involved in habitat occupancy.

The small pond on which the following observations were made was located on the property of Indiana University in Sec. 35, T-9-S, R-1-W of Monroe County, Indiana. The terrestrial features of the area are described by Cantrall and Young (1), and the general features of the pond as it was in 1908-1910 by Scott (5). At the time of Scott's studies the pond was

[1]Contribution No. 680 from the Zoological Laboratories of Indiana University aided by National Science Foundation grant G-2708 and U. S. Public Health Service grant RG-6411.

apparently permanent, but it was dry during August and through most of September in 1950, 1951, and 1952. The pond was destroyed during building operations in the area in April 1953.

Scott's Pond, as it was called locally, was originally a solution sinkhole enclosed in upland forest. The stoppage of the drainage into the underground strata was probably not begun until after the woodland had been cleared. By 1949, the pond had acquired a marginal rim which was either thrown up by plowing or was produced by erosion of the surrounding field. This rim allowed the pond to extend over a considerably greater area at maximum high water than it would have covered if level with the surrounding field.

The pond in 1908-1910, as described by Scott (5) was roughly oval, about 70 by 57 feet in dimensions at maximum. The greatest depth was about 46 inches, attained during the heavy spring rains. The situation did not seem to have changed significantly by 1949, except that the greatest depth was less, and the pond dried up each year during the late summer and fall droughts. Scott records that in 1887 the pond was about eight or nine feet deep ("deep enough to swim a horse"), and since in 1908-1910 it was less than four feet deep the rate of deposition was calculated to be over two inches per year. This rate, however, must have decreased if it was ever attained because the pond was still over three feet deep at the center at maximum in 1949.

The decrease in sedimentation rate was probably influenced by the discontinuation of cultivation of the surrounding field and also by decrease in the aquatic vegetation. Scott records *Typha* (cattails) as abundant, covering the shallower two-thirds of the pond. In 1949-1953, *Typha* was restricted to a small area of the east side, and was conspicuous only during the summer. In contrast, however, to Scott's description, during 1949-1953 terrestrial grasses, sedges, and some annual weeds which grew over most of the bottom during the periods in which it was dry, persisted even after the pond refilled in the fall. Scott mentions that the bordering weeds and sedges tended to cause the deposition of much of the silt washed in from the sides before it reached the water, but the weed zone seemed greatly extended by 1949 in comparison with his description. The strictly aquatic vascular plants in 1949-1952 were the same as those recorded by Scott (5): *Alisma plantago* L. and *Veronica* (probably *anagallis* L.), together with the emergent *Typha angustifolia* L.

The pond was visited on numerous occasions between October, 1949, and March, 1953. About 25 collections of water beetles were made using small screen dippers. Of these, 16 were large enough to represent a fairly random sample of the beetles present at the time of collecting. These 16 collections contain approximately 950 specimens representing 40 species in 7 families and are the main basis of the observations and conclusions. The pond was also observed repeatedly during every month of the year for changes in vegetation, but water beetles were not collected on every occasion.

I wish to acknowledge the assistance of Mr. Joseph E. Woodruff in mounting and preparing the specimens for study. Dr. Merle E. Jacobs also assisted with the collecting and made observations on the pond in the summer of 1950 when I was absent.

Seasonal Aspects

The seasonal aspects of the pond and the correlated changes in the water beetle fauna followed a general pattern as follows:

Late Summer and Early Fall: Scott's Pond was completely dry in August in 1950, 1951, and 1952. The bottom had large cracks across the mud by about August 10 in the central depression, and the bordering vegetation had begun to extend toward the center. By September the central depression was covered with a growth of small grasses, sedges, and herbs, apparently of species already present in the bordering zone of annual weeds. The cattails, *Typha*, persisted on one side of the pond and remained green and the annual weeds outside the cattail zone grew quite high during this period. Small shrubs of buttonbush, *Cephalanthus occidentalis* L., and a very few small red maple trees, *Acer rubrum* L., did not seem to be particularly affected by the drying of the pond. No water beetles could be found by digging in the bottom or by pulling up rooted vegetation in August or September. In late September the pond refilled, but as usual, no beetles were found for some time afterwards.

Fall: In October, water beetle adults were present in the pond but the number of species was limited. Some of the cattails and emergent grasses were still green at this time and some of the recently submerged terrestrial plants remained green beneath the water into the winter. Algae grew slowly on the submerged vegetation in early October, but were not very evident even in November. *Agabus disintegratus* and *Tropisternus l. nimbatus* were both observed swimming in the water along shore in some numbers. The species of *Laccophilus* were all present at the edges in small numbers. *Agabus punctatus* was found only in one area of the pond where a small stand of buttonbush had produced a partially shaded area with considerable leafy debris and dead wood in the water. This area persisted throughout the period of study and was obviously the main habitat of *Agabus punctatus*, *Hydroporus niger*, *H. rubilabris*, and a number of other species.

Winter: The winter aspect of the pond did not differ greatly from the fall except that the dead emergent vegetation in December and January had fallen into the water and begun to decay. Some herbs and grasses remained green on the bottom even beneath ice. Algae were now evident on both the dead and living vegetation in the water. In January the pond reached its maximum and overflowed through an outlet at the northwest corner. *Tropisternus l. nimbatus* remained very common in the winter as did *Agabus disintegratus*. *Laccophilus fasciatus* and *proximus* seemed to increase in abundance in December, possibly due to migration from other habitats, but *L. maculosus* disappeared and did not reappear until late spring. *Hygrotus nubilus* became more abundant in January and could be seen swimming over the bottom. *Agabus punctatus* remained common in December in the buttonwood area, but apparently declined somewhat in January.

Early Spring: The early spring or prevernal changes in the water beetle fauna were particularly striking and interesting. In February and early March a few submerged plants still remained green and the water was at its maximum. Algae was conspicuous on the vegetation and by late March had overgrown all dead vegetation. The *Laccophilus* species

practically disappeared during this period, but three forms appeared for the first time: *Haliplus ohioensis, Berosus fraternus,* and *B. peregrinus. Agabus aeruginosus* of which one specimen had been taken in January also apparently increased in February. *Haliplus ohioensis* was found in February, 1951, and in February, March, and April of 1952, but was not found in February, 1953.

Spring: During late March and through April, green algae became more and more conspicuous. Emergent grasses began to appear at the edges of the pond in April and algae grew abundantly on all dead vegetation. The water level receded from the January high during this period so that the pond gradually decreased in area and depth. *Haliplus ohioensis* largely disappeared by the middle of March although a few specimens persisted until later. The species of *Laccophilus* reappeared in April and continued in moderate numbers into the summer. The species of *Agabus* and *Tropisternus* remained about the same. *Dineutus assimilis* appeared in April and extended into June in 1952.

Late Spring: In May the cattails began to sprout above the water level, and filamentous algae (*Spirogyra* and others) began to form "greasy" masses in the center of the pond. The water level was now down about two or more feet from the January level and the pond was greatly reduced in size. Most of the water beetles seemed to be present in about the same proportions as before, but *Tropisternus l. nimbatus* was apparently very rare during this period.

Summer: By June emergent and floating vascular vegetation (*Typha, Alisma,* and *Veronica* along with some semi-aquatic grasses and others) was abundant around the edges of the water. The mass of algae in the pond was somewhat reduced, but it still formed semi-floating mats in places. By July, *Alisma* was growing over the entire bottom of the central depression in which the water was only about a foot deep. The algae had been greatly reduced by this time, however, probably due to the feeding of various invertebrates. Some beetles were taken in the pond commonly only during the summer period. *Hydrocanthus iricolor, Enochrus ochraceus,* and *Ilybius biguttulus* seem particularly characteristic of these summer conditions. *Agabus disintegratus* and *A. punctatus* along with *Tropisternus l. nimbatus* were correspondingly rare.

The Water Beetle Fauna

Table I lists the adult water beetles considered characteristic of Scott's Pond. Characteristic is here used in the sense of species likely to be encountered in such a situation and apt to complete their life cycles there. The species listed show a high frequency (regularity of occurrence) and a consistently high abundance (commonness) with some exceptions. The species which do not show a high frequency and high abundance are thought to be poorly represented in the sample because of the techniques used. Three of them (*Bidessus lacustris, B. suburbanus,* and *Hygrotus dispar*) are small and may have been overlooked at times when they were not particularly common. On the other hand, *Coptotomus longulus, Thermonectus basillaris,* and *T. ornaticollis* are medium sized, very active, species usually found in deeper water and may have escaped the collecting net.

TABLE I. Characteristic Adult Water Beetles of a Temporary Silt-Bottomed Pond in Southern Indiana

Species	S	O	N	D	J	F	M	A	M	J	J	A
DYTISCIDAE:												
Agabus disintegratus (Cr.)	—	5/1*	7/1	9/1	4/2	19/3	6/2	5/3	4/2	3/1	—	—**
" *punctatus Melsh.*	—	7/1	—	48/1	9/2	64/3	13/2	20/3	30/2	16/1	—	—
Bidessus lacustris (Say)	—	—	—	6/1	—	—	—	—	6/2	1/1	—	—
" *suburbanus* Fall	—	—	—	9/1	—	—	—	17/3	1/2	—	—	—
Coptotomus longulus LeC.	—	—	—	—	—	1/3	4/2	—	—	—	—	—
Hygrotus dispar (LeC.)	—	—	2/1	—	—	—	—	—	1/2	—	—	—
" *nubilus* (LeC.)	—	—	1/1	1/1	5/2	2/3	1/2	—	—	3/1	—	—
Hydroporus niger Say	—	1/1	—	—	2/2	6/3	2/2	1/3	8/1	—	—	—
" *rufilabris* Shp.	—	1/1	—	—	1/2	19/3	5/2	3/3	1/2	5/1	4/1	—
Laccophilus fasciatus Aubé	—	3/1	1/1	27/1	3/2	—	2/2	5/3	10/2	2/1	6/1	—
" *proximus* Say	—	5/1	1/1	21/1	5/2	—	—	4/3	1/2	1/1	5/1	—
Thermonectus basillaris (Harris)	—	—	—	1/1	1/2	—	—	—	—	—	—	—
" *ornaticollis* Aubé	—	1/1	—	4/1	—	—	—	—	—	—	—	—
HYDROPHILIDAE:												
Tropisternus l. nimbatus Say	—	11/1	1/1	38/1	19/2	1/3	13/2	6/3	—	1/1	—	—

* First number under month is total specimens taken; second number is number of collections made in that month from September 1949 to February 1953.

**Pond was completely dry in August and through most of September during both 1950 and 1951.

The species represented in Table I can be subdivided into at least three groups on the basis of known habitat preferences. One group is composed of the pioneer species which invade any newly formed body of fresh water during its early stages and then gradually decrease as the biota develops. These include *Bidessus lacustris*, *Hygrotus nubilus*, *Laccophilus fasciatus*, *L. proximus*, *Thermonectus basillaris*, and *Tropisternus l. nimbatus*. Since the pond dried up each year and thus essentially started over again, the presence and abundance of these forms is to be expected. This group represents derivatives of the western desert fauna, but none of the species are now found in the deserts. They may have evolved in connection with the prairie plains. All of them are certainly now more abundant than they were before the clearing of the forests, but there is no indication that their ranges have actually changed.

A second group of species is characteristic of silt-bottomed ponds, but does not occur regularly in new situations as pioneers. *Agabus disintegratus*, *Thermonectus ornaticollis*, and some of the seasonal or sporadic species are examples. These again may be relicts of the old prairie pond fauna. *Coptotomus longulus* may belong to this group although it is often found in more permanent ponds.

A third group, possibly a subdivision of the second, includes the remainder of the species in Table I. These are characteristically associated with silt-bottomed ponds, but only where there is some accumulation of organic debris: *Agabus punctatus*, *Bidessus suburbanus*, *Hygrotus dispar*, *Hydroporus niger* and *H. rufilabris*. In Scott's Pond these species were obviously associated with the fallen leaves and other debris beneath the small buttonbushes.

Some characteristic species of true detritus ponds also occurred in Scott's Pond, but they were mostly seasonal or erratic. Some of them, such as *Hydrocanthus iricolor* and *Hydrovatus c. pustulatus* were represented in Scott's original list (5) and were probably then characteristic. More recently, the detritus pond species increased as the vegetation in the pond increased in the spring while the pioneer species correspondingly declined.

Only a few unidentified larvae of *Hydroporus* and *Agabus* were taken in Scott's Pond in 1949-1953. In consequence, it is impossible to say whether all of the species thought to be characteristic actually completed their life cycles in the pond. The absence of larvae of *Laccophilus* in the collections is surprising.

Table II lists the species of adult water beetles taken in Scott's Pond on more than one occasion but only infrequently or during a restricted season of the year. Some of these seem to occur only at the season in which they were taken, for example *Haliplus ohioensis* and *Berosus fraternus*. Other species probably migrate into the pond during periods of maximum abundance in other situations, for example *Laccophilus maculosus* which is characteristic of more permanent ponds. Within this group of seasonal or sporadic occupants some species probably completed their life cycles in the pond. *Hydrocanthus iricolor*, for example, may have been a permanent inhabitant surviving from a period when the pond was permanent. The apparent absence of the species during most of the year, however, suggests a replacement of the population by migration.

TABLE II. Seasonal or Sporadic Adult Water Beetles of a Temporary Silt-Bottomed Pond in Southern Indiana

Species	S	O	N	D	J	F	M	A	M	J	J	A
DYTISCIDAE												
Agabus aeruginosus Aubé	—	—	—	—	1/2*	6/3	—	—	—	—	—	—
Copelatus glyphicus (Say)	—	—	—	4/1	—	3/3	3/2	—	—	—	—	—
Laccophilus maculosus Say	—	1/1	—	—	—	—	—	5/3	4/2	2/1	1/1	—
NOTERIDAE												
Hydrocanthus iricolor Say	—	—	—	1/1	—	—	—	—	—	—	10/1	—
HALIPLIDAE												
Haliplus ohioensis Wallis	—	—	—	—	—	52/3	12/2	1/3	—	—	—	—
GYRINIDAE												
Dineutus assimilis Kirby	—	—	—	—	—	—	—	1/3	2/2	2/1	—	—
HYDROCHIDAE												
Hydrochus rufipes Melsh?	—	—	—	1/1	—	—	—	—	24/2	2/1	—	—
HELOPHORIDAE												
Helophorus tuberculatus Gyll.	—	—	—	—	—	—	1/2	2/3	6/2	—	—	—
" *lineatus* (Say)	—	—	—	—	—	—	1/3	—	—	1/1	—	—
HYDROPHILIDAE												
Berosus fraternus LeC.?	—	—	—	—	—	6/3	3/2	3/3	1/2	—	—	—
" *peregrinus* (Hbst.)	—	1/1	—	—	—	7/3	3/2	—	—	—	—	—
" *striatus* (Say)	—	—	—	—	—	—	1/2	1/3	—	—	—	—
Enochrus cinctus (Say)	—	—	—	—	—	—	16/2	—	8/2	—	—	—
" *ochraceus* Melsh.	—	—	—	—	—	—	—	1/3	1/2	—	3/1	—
" *pygmaeus* (Fabr.)												
" *horni* Leech	—	—	—	—	—	—	—	2/3	3/2	—	—	—
" *perplexus* LeC.												
Hydrophilus triangularis Say	—	—	—	—	—	—	—	1/3	—	—	1/1	—

* See notes accompanying Table I.

Three of the species listed in Table II may represent part of a group of desert-prairie pond species. These are *Haliplus ohioensis*, *Agabus aeruginosus*, and *Berosus fraternus*. It is possible that these species have specialized life histories which allow them to pass over periods of drought. The appearance of teneral adults in the prevernal and vernal periods and the abundance of adults only at those times suggests that the larvae, pupae, or eggs must somehow pass over the period of drying in the late summer and early fall.

A similar correlation of the life cycle has been surmised in *Desmopachria mutchleri* Blatchley in Florida by Young (7). It is difficult, however, to make any positive statement as to the larval habitat of such species because like other drought-adapted forms they are so highly vagile that the habitats in which they appear as adults may be merely coincidental. However, the great abundance of *Haliplus ohioensis* in Scott's Pond in February and March during two of three springs and at no other time strongly suggests that the species completed its life cycle in the pond.

In addition to the species listed in Tables I and II, eight others were taken only once during the period of study and are considered erratic or accidental. Some of them are characteristic of situations with heavy accumulations of organic debris or detritus ponds: *Bidessus affinis* (Say), *Desmopachria convexa* (Aubé), *Hydrovatus c. pustulatus* (Melsh.), *Ilybius biguttulus* (Germ.), *Tropisternus b. blatchleyi* D'Orchymont, and *Tropisternus natator* D'Orchymont. The habitat correlations of the remaining two is not known: *Hydrochus subcupreus* Randall and *Helophorus lineatus* Say.

Comparison with Other Lists

A comparison of Scott's list of water beetles with the 1949-52 list indicates the change from relatively permanent to temporary. The species listed by Scott, with nomenclature revised, and a summary of his comments follows:

HALIPLIDAE:	*Peltodytes 12-punctatus* (Say)—always present, abundant.
	Peltodytes muticus (LeC.)—always present, abundant.
NOTERIDAE:	*Hydrocanthus iricolor* (Say)—throughout the year in considerable numbers.
DYTISCIDAE:	*Laccophilus maculosus* Say
	Laccophilus fasciatus Aubé—present in about equal numbers to preceding.
	Hydrovatus c. pustulatus (Melsh.) — present throughout the year.
	Coptotomus interrogatus (Fabr.) — taken in numbers at any season.
	Graphoderus liberus (Say) — one specimen June 6, 1910—probably just immigrated.
GYRINIDAE:	*Dineutus assimilis* Kirby—present from April to October.

HYDROPHILIDAE: *Tropisternus mixtus* (LeConte) — the commonest beetle in the pond, seen even beneath the ice in winter.

Berosus peregrinus (Herbst.)—not common.

The only notable species lacking from this list but present in the 1949-1953 period are: *Agabus disintegratus*, *Tropisternus l. nimbatus*, and *Laccophilus proximus*. It is possible that Scott confused the first with *Coptotomus* and the last with *L. maculosus*, but he could hardly have missed *nimbatus* if it had been present. Notably lacking in our list, however, is any species of *Peltodytes (=Cnemidotus)* which are relatively good indicators of permanent water. Also the rarity of *Coptotomus* in our collections probably reflects the fact that the water had become shallower and less permanent, since the species of this genus are normally bottom feeders in fairly deep water out beyond the marginal vegetated zone. *Tropisternus mixtus*, another permanent pond species, is not represented in our list, although it may be considered replaced by *T. blatchleyi blatchleyi* or *T. natator* which were not at that time separable. The decline in occupancy of the pond by *Dineutus assimilis* was probably due to the decrease in size of the area of open water during much of the year.

The examination of a number of lists of aquatic beetles from small ponds in other regions shows some interesting parallels to Scott's Pond.

Dickinson (2) lists 33 aquatic beetles from a small field pond in Alachua County, Florida. This pond, also studied by the present writer, was somewhat similar to Scott's Pond, probably having arisen from a small sinkhole originally in forest. It was, however, considerably richer in vegetation and at times may have connected with other ponds in the vicinity. Unlike Scott's Pond, fairy shrimp were present at times during the year. Considering the separation in space and the very different faunas of the surrounding areas, the similarity of the water beetles of the two ponds is remarkable. The following species are identical in the two lists: *Agabus punctatus*, *Laccophilus fasciatus*, *L. proximus*, *Thermonectus basillaris*, *Tropisternus b. blatchleyi*, and *T. l. nimbatus*. Three of these were present in high frequency and abundance in both the Florida and Indiana ponds: *A. punctatus*, *L. proximus*, and *T. l. nimbatus*. Considering ecological equivalents or subspecies the following additional correspondences are evident: *Coptotomus i. obscurus* Sharp, *Copelatus c. chevrolati* Aubé (equivalent of *glyphicus*), *Hydroporus falli* Blatchley (equivalent of *niger*), *Hydrocanthus regius* Young, *Haliplus annulatus* Roberts (equivalent of *ohioensis* and also abundant only in prevernal period), *Dineutus c. carolinus* LeC. (equivalent of *assimilis*), *Hydrochus foveatus* Hald. and *H. simplex* LeC. (equivalent of *rufipes*), *Berosus infuscatus* LeC. (equivalent of *fraternus*), and *Tropisternus natator* subsp.? (the *glaber* of Dickinson's list). Considering the species listed by Scott (1910), *Graphoderus liberus* also occurred in both ponds, and *Peltodytes floridensis* Matheson of the Florida list is equivalent to *P. 12-punctatus*. Thus the total Scott's Pond list contains 7 identical, 2 only subspecifically different, and 8 ecologically equivalent species of the Florida list.

Kenk (3) lists the aquatic beetles from a number of small ponds near Ann Arbor, Michigan. The ponds considered are not as similar to Scott's

Pond in history or general features as the one in Florida studied by Dickinson. They are also near the northern limits or outside the ranges of some of the species found in Scott's Pond, but of 32 species listed from temporary ponds, the following also occurred in Scott's Pond: *Bidessus affinis, Desmopachria convexa, Hydroporus niger, Hydrovatus c. pustulatus, Helophorus lineata, Berosus striatus, Hydrophilus* (prob. *triangularis*), *and Enochrus ochraceus.* In more permanent ponds Kenk also found *Graphoderus liberus, Laccophilus maculosus, Dineutus assimilis,* and *Hydrocanthus iricolor.*

Needham and Williamson (4) list 28 species of Dytiscidae collected in a small permanent pond at Lake Forest, Illinois. Their list contains the following species also found in Scott's Pond: *Agabus disintegratus, Bidessus affinis, B. lacustris, Coptotomus interrogatus, Hydrovatus c. pustulatus, Hygrotus dispar, H. nubilus, Laccophilus fasciatus, L. maculosus, L. proximus,* and *Thermonectus basillaris.*

Sherman (6) says that almost exactly the same species as those in the Needham and Williamson list occur in meadow ponds in New York, along with *Desmopachria convexa* and *Hydrocanthus iricolor.*

Summary and Conclusions

Forty species of water beetles (Coleoptera) were collected in a small, silt-bottomed temporary pond in southern Indiana at various times between 1949 and 1953. Eight species occurred in nearly every month except August and September when the pond was dry. These, and six other species, are considered *characteristic.* The characteristic species include (1) pioneer forms which migrate into any body of water and are characteristic of newly formed situations, (2) some possible relicts of prairie pond situations, and (3) a few species characteristically associated with organic debris in silt ponds but not detritus pond species. Of the remaining species, 18 are either *seasonal* or *sporadic.* The strikingly seasonal species may include specialized desert-prairie pond forms which can survive even during periods of complete drying. *Haliplus ohioensis* Wallis may be such a drought-adapted species. Adults of this species appeared in the pond in February in two successive years but were absent the next year. Sporadic species apparently entered the pond during periods when they were abundant in other habitats. The eight species taken only once in the pond are considered *erratic* or accidental.

It is concluded from the data presented and from a consideration of other studies that the characteristic species of water beetles in temporary ponds are the adventitious pioneer forms. These form a remarkably constant nucleus over a very wide area and are generally the major predators and scavengers. The greater part of the list of species of any temporary pond, however, is largely composed of species which migrate in from habitats in the surrounding area and are often characteristic of other habitats in the region. Some of these migrants are present only as adults and perhaps only fortuitously; others which find suitable breeding places in the pond persist for longer periods.

There is no clear evidence of the extension of any of the species into new regions, but all of the species considered characteristic must have increased in number at least with the increase in temporary ponds.

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Musca autumnalis (DeGeer), A New Livestock Pest in Indiana[1]

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A new dipterous livestock pest was observed on cattle in Indiana this year. Specimens were collected from cattle at the Herbert Davis Forestry Farm, Randolph County, east central Indiana, June 3, 1959. These specimens were forwarded to C. W. Sabrosky at the U. S. National Museum and were identified as *Musca autumnalis* (DeGeer). This new pest, *M. autumnalis*, although similar in appearance to the housefly, *M. domestica*, is somewhat larger and is darker in color. Taxonomic characters on the upper surface of the head are useful in separating the two species. Unlike *M. domestica*, the eyes of males of *M. autumnalis* are contiguous above or are separated by less than the width of the ocellar triangle. Females are separated by comparing the width of the frontal stripe with the orbital stripe. The grey orbital stripe of *M. autumnalis* females is nearly equal in width to the black frontal stripe while the orbital stripe of *M. domestica* is less than one-third as wide (Fig. 1).

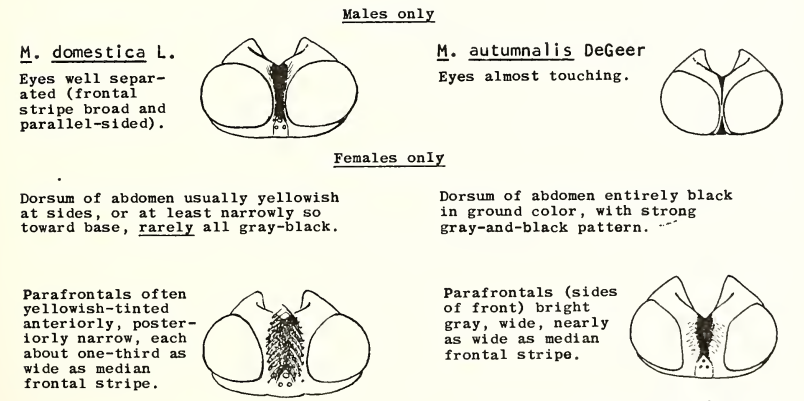
Males only
M. domestica L.
Eyes well separated (frontal stripe broad and parallel-sided).
M. autumnalis DeGeer
Eyes almost touching.
Females only
Dorsum of abdomen usually yellowish at sides, or at least narrowly so toward base, rarely all gray-black.
Dorsum of abdomen entirely black in ground color, with strong gray-and-black pattern.
Parafrontals often yellowish-tinted anteriorly, posteriorly narrow, each about one-third as wide as median frontal stripe.
Parafrontals (sides of front) bright gray, wide, nearly as wide as median frontal stripe.
Curtis W. Sabrosky
Insect Identification and Parasite Introduction Research Branch,
U. S. Dept. of Agriculture
Cooperative Economic Insect Report, Vol. 9(45): 11-6-59.

Figure 1

According to Vockeroth (2), *M. autumnalis* was first collected in North America in Nova Scotia, Canada, 1952. The first United States records were from New York State, 1953, and from Virginia, 1956, according to Sabrosky (1). During the past summer, however, first records were reported from 12 northeastern and north-central states. These states were Indiana, Ohio, Illinois, Wisconsin, Michigan, Delaware, Massachusetts, New Hampshire, New Jersey, Pennsylvania, Vermont, and West

[1]Purdue University, Agricultural Experiment Station Journal Paper No. 1543.

Virginia. In Indiana, infestations of economic importance caused great annoyance to both beef and dairy cattle. Horses were also infested.

These flies cluster around the eyes and nostrils of cattle and horses where they feed on mucus and watery secretions. This feeding activity causes annoyance and extreme irritation to the infested animals. Although *M. autumnalis* is unable to inflict feeding wounds, they have been observed feeding on blood and exudation from wounds made by other insects or from other causes. It has been suggested that these flies may also be possible mechanical vectors of infectuous eye diseases of cattle.

M. autumnalis may overwinter in this state by hibernating in buildings or other protected environments. Their appearance in homes during the winter months may coincide with cluster fly infestations. During the summer, eggs are laid on fresh manure. The yellowish maggots are found here until their maturity. Pupation occurs in the soil or on the surface of the soil beneath the manure. The adults are active from spring until late fall. The number of generations each year in Indiana is not presently known.

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Insects and Other Arthropods of Economic Importance in Indiana in 1959[1]

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Weather conditions in Indiana which influence insect occurrence and abundance were in sharp contrast to those experienced in 1957 and 1958. The spring months were near normal, characterized by plentiful rainfall and temperatures only slightly above the averages expected. Insect hatching and emergence responded normally to these early conditions. Early in July, drought conditions began to develop in central and northern Indiana and continued through August with accompanying high temperatures; humidity was high. September moisture conditions improved and most agricultural crops matured successfully although earlier than is customary. In general the climatic conditions favored most economically important insects in this region. One new pest, the cattle face fly, appeared in large numbers and is described below.

A review of the records and abundance of certain species follows:

Field and Crop Insects

Corn earworm [*Heliothis zea* (Boddie)]. Tippecanoe County: According to light trap collections, corn earworm moths were about five times more numerous in 1959 than in 1958. From June 12 to September 20, 3,636 moths were collected at a single light trap as compared to 752 in 1958. The peak of collections in both years was during the week of September 4-10, 2,307 moths being collected during this period in 1959 and 368 in 1958. Sweet corn silking during the early part of September was very heavily attacked with 90% infested ears. Lawrence County: Moths were about 2½ times more abundant at light traps in 1959 than in 1958. However, only about one-tenth as many were collected in this county as in Tippecanoe. The current fall survey of field corn showed a 60% increase over 1958 with an average infestation of 28%. Heaviest infestations, ranging up to 71%, occurred in the southern tier of counties.

European corn borer [*Pyrausta nubilalis* (Hbn.)]. Tippecanoe County: The number of first generation moths caught at light traps was about the same in 1958 and 1959, but the infestation in early sweet corn was about twice as great in 1959 as in 1958. The August and September collections of moths were about twice as large in 1959 as in 1958. In 1958 there were two distinct periods of moth flight—May 30 to July 2 and July 31 to September 3. In 1959 there were three distinct periods of flight—May 24 to June 17, July 16 to August 13, and August 27 through September 30. These distinct periods of flight seem to indicate that there were three generations of the corn borer in Tippecanoe County this year. Lawrence County: There were about three times as many moths collected at light traps in 1958 as in 1959. In both years there seemed to be three generations per year. The 1959 fall survey showed a 50% increase in the average

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[2]Contributions received from members of the Department of Entomology.

number of borers per 100 corn plants (65) although the per cent of plants remained constant with last year. Greatest infestation occurred in the north-central and northeast areas of Indiana where the maximum number of borers per infested plant was 2.7.

Armyworm [*Pseudaletia unipuncta* (Haw.)]. Moths were moderately abundant in late spring, but larval damage was very moderate. An abundance of grass at that season of the year probably prevented the development of an economic problem.

Fall armyworm [*Laphygma frugiperda* (J. E. Smith)] was of little economic importance in Indiana in 1959. Light trap catches were low and reports of field observations showed little or no infestation in field corn. Extremely late home garden sweet corn was severely infested in Tippecanoe County. The larvae worked in the whorl, destroying the bud.

Common stalk borer [*Papaipema nebris* (Guenee)]. These larvae caused damage to early corn, especially in fields along weedy fence rows. Their occurrence was general over southern, western and northern counties.

Cutworms—Several species were common in the spring with significant losses reported to corn and mint. The principal species on corn, the black cutworm, *Agrotis ypsilon* (Rott.), was reported from many sections of the state. Corn planted directly in newly plowed clover fields was the most seriously damaged. Control in early cultivated corn was relatively difficult.

Webworms [*Nomophila noctuella* (D. and S.)] on corn planted in fields following sod were reported as important economically from many areas of the state.

Wireworms—Because of a low point in the population cycles of these insects and because of the increased number of treated fields, wireworms were not important this season.

Thrips on corn—A severe infestation of thrips on late planted corn occurred in Clay County, Indiana in late May and early June. Visual counts on leaves of corn 8-12 inches tall averaged 75-150 insects per leaf. Infested corn lacked the glossy leaf appearance and was a grayish green color. Leaves were flaccid to the touch. Several hundred acres were treated, but locally heavy rains also reduced the populations and the corn plants made a normal recovery and outgrew the injury.

Corn rootworms—Beetles of both the northern [*Diabrotica longicornis* (Say)] and the southern [*D. undecimpunctata howardi* Barber] species were numerous during July and August. Some scattered reports were received on root injury to corn.

Corn leaf aphid [*Rhopalosiphum maidis* (Fitch.)]. Infestations were the heaviest recorded in recent years. Nubbins and barrenness were extensive with greatest losses in the northern tier of counties and through the north-central part of the state. Average aphid infestations in these regions ranged from 36-80%. From the north to south, the most northern fourth averaged 4.5% loss, the next fourth, 11.2%, followed by 3.3% with no measurable loss in the most extreme southern fourth.

Japanese beetle [*Popillia japonica* (Newm.]. Although many new locations were found this past summer, populations in established areas were lower than for several years. In Newton County, adult beetles were

scarce on smartweeds in the area where they have been abundant in past years. Damage to soybeans was slight and probably of no economic importance. High temperatures during July and August and lack of soil moisture possibly reduced beetle activity, especially egg-laying of females. By October 1, most larvae were still in the first and second instar. New locations include Seymour, Montezuma, and Crawfordsville.

Sorghum webworm [*Celama sorghiella* (Riley)]. This insect was not as abundant in Indiana this year as compared with last year, due principally to better growing conditions and more uniform development of plants. One 40 acre field of late sorghum in Posey County averaged 80% of the heads infested with 5–6 larvae per head. Adults were collected in Daviess County in mid-September.

The corn earworm infested sorghum rather severely with evidence of damage in most of the heads examined in Knox County.

Tomato fruitworm [*Heliothis zea* (Boddie)]. This insect was locally severe about August 1 when tomatoes were ripening but before corn was in silk. As soon as silks appeared, infestation of tomatoes decreased markedly. Moths were present in sizable numbers through late summer but no serious infestation of tomatoes occurred.

The fruit fly [*Drosophila melanogaster* Meig.] in tomato fields ranged from extremely low populations about August 10 to extremely high populations by Labor Day, September 7. This period was characterized by high temperatures and high humidity.

Tobacco hornworm [*Protoparce sexta* (Johan.)] on tomato. Second generation populations of this insect were abnormally high in southeast and south-central Indiana. Parasitism by *Apanteles congregatus* (Say) ranged from 50–100 per cent.

Bean leaf beetle [*Cerotoma trifurcata* (Forst)]. Contrary to the trend in recent years, this insect did not increase on soybeans and was not considered economically important.

Cucumber beetles—The striped species [*Diabrotica vittata* (F.)] was common early in the season, but later the spotted beetle [*D. undecimpunctata howardi* Barber] became exceedingly abundant and destructive. The spotted beetle injured various cucurbits, green beans, soybeans, and many varieties of flowers.

Onion maggot [*Hylema antiqua* (Meig.)]. Infestations of this pest were very low in 1959. This is the usual condition in Indiana. Maggots resistant to chlorinated hydrocarbon insecticides occur only in Lake County.

Aphids on potatoes—Several potato growers reported aphids on their crops. The species involved were *Myzus persicae* (Sulz.) and *Macrosiphum solanifolii* (Ashm.).

Flea beetles on potatoes—These pests were abundant on potatoes this year and repeated applications of the proper insecticide were necessary to hold them in check. In two fields, even dieldrin failed to give the expected control.

Flea beetles on turnips—Larvae of the flea beetle (apparently *Systena blanda* Welsh.) caused heavy losses to turnips in late October in central Indiana.

Mint looper [*Rachiplusia ou* (Guerin)]. The population of this pest was quite low this summer. A few fields had some damage in mid-July, about a month later than normal.

Two-spotted mite [*Tetranychus telarius* (L.)]. This pest was serious on melons in southern Indiana in mid-July and was abundant on mint grown on lighter soils in early August. In late summer, it became abundant on many flowering plants.

Meadow spittlebug [*Philaenus leucopthalmus* (L.)]. The spittlebug was the most serious insect problem on alfalfa and clover in Indiana during the 1959 season. It is believed that the infestation was the heaviest ever observed in the state. Most serious infestations occurred in the eastern part of the state. In the area south of Richmond and east of Shelbyville extending to the Ohio River, the infestations were as high as 7.2 nymphs per clover stem. The total state loss was estimated at $12,000,000.

Potato leafhopper [*Empoasca fabae* Harris] developed very heavy and severe infestations on the second cutting of alfalfa during the month of July. Losses were severe with considerable yellowing and stunting of the crop. In the case of potatoes, commercial growers had to repeat control operations at weekly intervals to contain the hoppers. Serious damage to garden beans was also observed.

Spotted alfalfa aphid [*Therioaphis maculata* (Buckton)] was found in Indiana for the first time in two years on September 22. Infestations were very low, although specimens were collected in the Wabash River bottom from Vincennes south and along the Ohio River extending from Mount Vernon east to Clark County. This insect, which has not succeeded in overwintering in Indiana, followed the same pattern of infestation as noted previously, that of moving up the Wabash and Ohio River valleys. Climatic conditions favored the re-entry of this insect into the state.

Clover head caterpillar [*Grapholitha interstinctana* (Clem.)] was again abundant on red clover in southeastern Indiana, particularly in Decatur, Rush and Shelby counties. Several other species of lepidopterous caterpillars were unusually abundant on legumes during the latter part of the summer in the southern third of the state. These were the green cloverworm [*Plathypena scabra* (F.)], the clover looper [*Caenurgina crassiuscula* (Haw.)], the garden webworm [*Loxostege similalis* (Guen.)], the alfalfa caterpillar [*Colias philodice eurytheme* Bdv.] and the corn earworm [*Heliothis zea* (Boddie)].

Plant bugs—Populations of the tarnished plant bug [*Lygus lineolaris* (P. de B.)], the rapid plant bug [*Adelphocoris rapidus* (Say)] and the alfalfa plant bug [*Adelphocoris lineolatus* (Goeze)] were widespread and quite abundant over the state.

Hessian fly [*Phytophaga destructor* (Say)]. Infestations by this insect have been low for several years but are now on the increase, particularly in the eastern part of the state. Farmers in the Delaware and Randolph County areas had some economic loss and experimental plots showed losses as high as 8–10 bushels of wheat per acre. Fall infestations in the same area were significant.

Clover leaf weevil [*Hypera punctata* (F.)], which is normally a problem on red clover and alfalfa in the early spring, was of much less significance in 1959.

Grasshoppers—These insects were non-economic to light in abundance throughout the state. Damage to crops occurred only in extremely localized areas. Principal species: *Melanoplus femur-rubrum* (De G.). Considerable damage occurred in some tomato fields with the additional factor of feeding scars being excellent oviposition sites for *Drosophila* spp.

Fruit Insects

Codling moth [*Carpocapsa pomonella* (L.)]. Populations of this insect were generally low during 1959.

Oriental fruit moth [*Grapholitha molesta* (Busck)] was present in low numbers, except for a few orchards in Knox County.

Apple maggot [*Rhagoletis pomonella* (Walsh)]. This insect emerged over a prolonged period and was present in large numbers in untreated orchards in the northern half of the state. Flies were trapped as far south as Orleans.

Rosy apple aphid [*Anuraphis roseus* Baker]. No major injury by this insect was observed during the year.

Apple aphid [*Aphis pomi* DeG.] was abundant in late March and during late May. The wet, cool weather caused troublesome populations in some orchards, especially those with young, non-bearing trees. During early June, several infestations around Vincennes needed control.

Forbes scale [*Aspidiotus forbesi* Johns.]. Infestations were generally light throughout the state with a few orchards showing high populations in mid-May.

Mite populations were high this year. Weather conditions, particularly during May and June, were ideal for mite build-ups and thorough control measures were needed to keep them down. European red mite [*Metatetranychus ulmi* (Koch)] was dominant until late June, but the two-spotted spider mite [*Tetranychus telarius* (L.)] became the more serious problem for most peach and apple growers from the first week of July on.

Tobacco Insects

Tobacco hornworm [*Protoparce sexta* (Johan.)]. Tippecanoe County: According to light trap records, there were about six times as many moths in 1959 as in 1958. There were two distinct generations in 1959 as compared to one in 1958. Damage to untreated tomatoes was severe in 1959 both from the viewpoint of fruit injury and defoliation. Lawrence County: According to light trap records, the first generation was twice as abundant in 1958 as in 1959. The second generation was slightly more abundant in 1959. Jefferson County: Injury to untreated fields of tobacco was about the same in 1959 as in 1958. However, the first generation injury was more severe in 1959 due to the plants being small at the time of infestation. Many growers whose fields were not protected by light traps had to apply insecticides once or twice during the season.

Tomato hornworm [*Protoparce quinquemaculata* (Haw.)]. Tippecanoe County: According to light trap catches, moths were about three times as abundant in 1959 as in 1958. Larvae were common in untreated tomato fields late in season but not as abundant as *P. sexta*. Lawrence County: First generation moths were about twice as abundant at light traps in 1958 as in 1959. Abundance of second generation moths was about

the same in the two years. Jefferson County: In 1959, as in other years, very few *P. quinquemaculata* larvae were found feeding on tobacco.

Tobacco flea beetle [*Epitrix hirtipennis* (Melsh.)] was not economically important this year.

Tree and Shrub Insects

The Zimmerman pine moth [*Dioryctria zimmermani* (Grote)] continues to be important in pine plantings with infestations in untreated areas as high as 30 per cent. This insect was discovered in white pine for the first time in Indiana (LaPorte County).

European pine shoot moth [*Rhyacionia buoliana* (Schiff.)] larvae were abundant throughout northern Indiana in May and early June. The most southern penetration of this insect in the state has now been recorded from DuBois County in Scotch pine.

Bagworms [*Thyridopteryx ephemeraeformis* (Haw.)] were not as common in 1959 as in the recent past, but they continued to be important in some areas on both evergreens and deciduous plants. The decrease is attributed to severe winter conditions.

The Mimosa webworm (*Homadaula albizziae* Clark) continues to spread throughout the state on honey locust trees. It was reported from Lake County, a point marking its farthest northward penetration in the state. The insect completely defoliated most honey locust trees in the southern part of the state in August and September.

The elm leaf beetle [*Galerucella zanthomelaena* (Schr.)] was exceptionally heavy on Chinese elms from Lafayette south. Many trees were completely brown as a result of larval feeding in August.

The Columbian timber beetle (*Corthylus columbianus* Hopk.) was found heavily infesting soft maple, oak and sycamore in the southwestern part of Indiana. The fungus associated with this ambrosia beetle stains the wood and ruins the trees for lumber. This is considered a serious economic situation.

A leafroller (*Tortrix pallorana* Rob.) was common in 2–3 year old pine plantations in northern Indiana. It frequently ruins Christmas trees for commercial production.

The smaller European elm bark beetle [*Scolytus multistriatus* (Marsh)], the common vector of Dutch elm disease, was noted almost continuously from May 20 to September 23, indicating an overlapping of generations.

Two galls, the succulent oak gall (*Andricus palustris* O. S.) and the oak wool sower (*Andricus seminator* Harr.), were unusually abundant on pin and white oaks respectively.

Two spittlebugs (*Clastoptera proteus nigricollis* Fitch and *Clastoptera obtusa* Say) were abundant on dogwood and ironwood trees in the Lafayette area in early June.

Fletcher's scale (*Lecanium fletcheri* Ckll.) was unusually abundant on yews, junipers and arbor vitae throughout the state.

Cottony maple scale [*Pulvinaria innumerabilis* (Rathv.)] occurred in unusual numbers on silver maples throughout the state.

Lecanium scales of several species were unusually abundant on hickory, oak and other shade and ornamental trees.

Livestock Insects

House fly (*Musca domestica* L.). This insect continues as the primary insect pest of dairy barns and homes. Farms where sanitary procedures were not rigidly pursued had enormous populations of flies late in the season.

Horn fly [*Siphona irritans* (L.)] was present in moderate numbers throughout the summer on untreated cattle. Numbers ranging up to 2000 on bulls in early June.

Horse flies (*Tabanus atratus* Fab. and *T. sulcifrons* Marquart) were extremely abundant in the northeastern section of the state during the last two weeks in July and the first two weeks in August. Counts average 25 "strikes" per minute.

The "face fly" (*Musca autumnalis* De G.). This fly was reported for the first time in the midwest in Randolph County, Indiana, on June 3. The new pest spread rapidly and generally over the state and caused extreme harassment to cattle in the northern half of the state. It also entered houses in this area. The fly feeds on secretions of the nostrils and eyes of animals, causing severe eye irritation. It is anticipated that the adult will overwinter in houses and buildings.

Pests of Men and Households

Cat flea [*Ctenocephalides felis* (Bouché)]. There were numerous inquiries concerning the control of this insect from various portions of the state. Many of the inquiries were accompanied by the comment that chlordane had been tried as a means of control and had been ineffective.

Subterranean termite [*Reticulitermes flavipes* (Kollar)]. Inquiries concerning this insect have been numerous. Most of these inquiries involve remedial measures, but there seems to be a slight increase in the interest of the general public concerning pre-construction treatment.

Ticks—The brown dog tick [*Rhiphicephalus sanguineus* (Latr.)] was rather numerous early in the summer but was not quite so numerous after about the middle of July. This was also true of reports on the American dog tick [*Dermacentor variabilis* (Say)].

Black carpet beetle [*Attagenus piceus* (Olivier)]. Numerous larvae of this insect have been submitted during the year. A lesser number of *Anthrenus* spp. have been received.

The elm leaf beetle [*Galerucella xanthomelaena* (Schr.)] was quite troublesome as an occasional household invader during the fall.

Field crickets (*Nemobius* sp.) were very abundant in late July and throughout August and were the subject of numerous complaints. Motels especially were troubled by the nocturnal invasions of these insects.

Swallow bug (*Cimexopsis nyctalis* List). The first Indiana record of this insect was from Rush County this summer. This insect is a parasite of the chimney swift, *Chaetura pelagica* (Linnaeus), and although it very likely has been a part of the Indiana fauna for some time, it had not been reported previously.

German cockroach [*Blattella germanica* (L.)]. This structural pest continues to increase both in number and importance due primarily to its resistance to chlorinated hydrocarbon insecticides and associated changes in its habits.

Hover flies *(Syrphidae)* of several species were very annoying to persons in late summer.

Miscellaneous Insects

A variety of wood-boring insects, some of these usually considered to be uncommon and insignificant, were observed in some numbers.

A xiphydriid (*Xiphydria maculata* Say) was especially numerous and oviposition was heavy in storm-damaged limbs of silver maple and hackberry in the Lafayette area.

The pigeon tremex (*Tremex columba* L.) was more numerous than in past years, especially so at LaPorte, where it was observed on dead and dying sugar maple and American elm.

The hackberry engraver (*Scolytus muticus* Say) emerged in numbers from storm damaged hackberry at Lafayette.

The currant borer [*Ramosia tipuliformis* (Clerck)] killed every currant plant in a shipment received from a mail order house by a Lafayette resident. The infestation originated during or prior to shipment.

The bald-faced hornet [*Vespula maculata* (L.)] and a yellow-jacket [*Vespula maculifrons* (Buysson)] increased their nesting activities in residential areas and were the sources of numerous inquiries. One death, at Martinsville, was attributed to multiple stings.

Many inquiries were received concerning a large leafhopper [*Oncometopia undata* (Fabr.)] which occurred in numbers on many plants.

A fungus [*Entomophthora muscae* (Cohn) Fresenius] attacked a number of species of flies of different families resulting in quite spectacular assemblages of dead flies.

A millipede [*Pleuroloma butleri* (McNeill)] was reported cutting off soybeans at Elnora.

Mayflies occurred in such tremendous numbers in the Bedford area as to cause several highway accidents.

The insect situation in Indiana returned to what may be described as essentially normal due to a combination of hot, humid weather and adequate crop production.

Tortrix pallorana Rob., A Pest of Pine Trees in Indiana[1]

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The leafroller, *Tortrix pallorana* Rob., has been found annually since 1955 to be a common pest of young pine trees in Indiana. Infestations as high as 30 per cent have been observed in several pine plantations. McDaniel (5) reported the same pest in Michigan in 1936 with infestations as high as 95 percent. This insect attacks all of the commonly grown species of pine, including jack, red, Scotch and white pines.

The injurious stage of the leafroller is the larva. During April and May, the greenish larvae, which fed on other hosts the previous fall, migrate to pine and web together the terminal and lateral areas of the soft new growth and feed on the needles and tender bark. Severely scarred twigs break off and, frequently, less severely injured branches exhibit fasciation. This injury is most damaging in nurseries and young pine plantations (Fig. 1). When the terminal area of a young pine tree is

Fig. 1. Injury to a Scotch pine seedling, note the central leader which has broken over as a result of the feeding of *Tortrix pallorana* Rob.

killed, the tree is ruined for either ornamental use or for a Christmas tree.

At LaPorte, Indiana, the adult moths were collected in large numbers in a "black light" insect trap early in June, 1959. The peak of adult emergence occurred on the night of June 7 when 49 adults were captured. Scattered emergence continued until about June 18. When the adult moths were disturbed, they made short flights near the host plant. The adults of the second generation emerged from July 25 until September 11,

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with peak emergence on August 21. The second generation, however, did not attack pine in the fall. The new growth of pine had hardened by July and was apparently no longer suitable for food. A similar observation was reported by McDaniel (5).

The pale green eggs are laid in shingled masses on the leaves of the host plants, other than pine. When ready to hatch, they become orange in color. Snow and McClellan (13) report an average of 61 eggs per mass.

This leafroller is polyphagous and has been reported to attack a large number of host plants: Leonard (4) reported cherry, silphium, verbena and clover (wild) in New York; Dean (1), Smith et al. (11) and Snow and McClellan (13) reported its occurrence on alfalfa in both Kansas and Utah; Schott (9) reported it on roses in New Jersey; Smith (12) found it on strawberries in Missouri; McDaniel (5) reported it on pines in Michigan; Newcomer and Carlson (8) added apple, pear, asparagus, sweet clover, dock, goldenrod, lambsquarter, milkweed, mullein, sumac, sycamore, Canada thistle and willow to the list from Washington; and Neunzig and Gyrisco (7) reported it on birdsfoot trefoil in New York. The summer generation of the leafroller in Indiana apparently feeds on some of the above hosts during July and again in the fall.

In Indiana, *T. pallorana* Rob., or its injury, has been observed on pine in widely separated regions of the state, including Elkhart, Fulton, Harrison, LaPorte, Lawrence and Starke counties.

Frequently, a related species, *Platynota flavedana* Clem., has been found attacking pine along with *T. pallorana* Rob. The larva of *P. flavedana* Clem. is brown and easily distinguished from the green larvae of *T. pallorana* Rob. Light trap catches of the adults of *P. flavedana* Clem. indicated a life history almost identical to that of *T. pallorana* Rob., but the frequency of its appearance on pine and in light traps was much lower.

Summerland and Hamilton (14) noted *P. flavedana* Clem. as injurious to peaches in southern Indiana, Illinois and Kentucky; Smith (10) listed it as a general feeder in New Jersey; Forbes (2) reported this species as generally distributed in New York; Hamilton (3) discussed it as a pest of roses in New Jersey; and Neiswander (6) found it injuring strawberries in Ohio.

Control of leafroller injury to pine trees involves both weed control, to eliminate its other hosts, and spraying the pine trees early in April with an insecticide, such as TDE (Rhothane), to kill the larvae.

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The Effect of Japanese Beetle Feeding on the Yield of Soybeans[1]

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The Japanese beetle was first found in Indiana in 1934 and now occurs in over 50 localized areas in the state. Most of these infestations are confined to urban areas where the feeding habits of larvae and adults are similar to those in the eastern states. However, some infestations do occur in rural areas where the normal food of the adult, the foliage of trees and shrubs, is scarce. This is especially true in Newton County where the original infested area of 1,000 acres found in 1953 had increased to over 100,000 acres by 1959. In such rural areas the principal food of the adult has been the foliage of smartweeds and soybeans. Larvae are more abundant in the weedy and grassy areas, although many are able to complete development in corn and soybean fields. Because of the economic importance of the soybean crop to Indiana farmers, reduction in yields from either beetle feeding on the foliage or larval feeding on the roots would be of special concern.

Field observations and trapping records in the Newton County area indicate that the first beetles appeared between June 20 and 27. Populations increased gradually and usually reached a peak around July 20. However, the finding of newly emerged beetles as late as August 10 indicated either a long emergence period or perhaps individuals with a life cycle differing from the normal. The preferred food of beetles in this region has always been smartweeds, but as the numbers of individuals and mating activity increased, beetles scattered throughout soybean fields. Regardless of the food plant, beetles tended to congregate in groups of two to six or eight and to feed on the sunny upper leaves. On soybeans feeding continued for a few hours up to a day before the beetles scattered to new locations.

Observations in the Newton County area indicated that the beetle population was highest in 1957 and dropped in 1958 and again in 1959. Beetle counts were made in the same two fields in all three years and showed a high peak in 1957 of 42 beetles per 100 feet of soybean row. Beetle numbers, of course, varied in the surveyed sections of rows with the presence or absence of smartweed and with the temperature, as more flights and other activity occurred when temperatures were between 80 and 90° F. The number of leaflets damaged ranged from three to six per infested plant or perhaps 5 to 10 per cent of the total foliage. Even in this field only about one plant in 20 suffered damage at some time during July and August. Thus the loss from beetle feeding was less than one per cent of the total foliage.

An exceptionally heavy population of beetles was found in 1957 on 12 rows of soybeans used as a border around a corn field. They were first observed on July 29 and averaged 500 per 100 feet on the outside row and totalled some 36,000 beetles per acre. This concentration was perhaps

[1]Purdue University Agricultural Experiment Station Journal Paper No. 1522.

caused by a forced migration from an adjacent weedy, low area following heavy rains and flooding. On August 2 the farmer sprayed with DDT and killed all beetles present. During the five or six days that the insects were feeding they destroyed about 10 per cent of the foliage. The possible loss to this field, if untreated, was estimated at about 30 per cent of the foliage. This entire field was planted to soybeans in 1958 and the border area had less than two beetles per 100 feet of row, while counts in 300 feet (in corn the previous year) were around 30.

In addition to the amount of feeding a second factor influencing the extent of loss to soybean yields was the stage of plant growth at the time of beetle feeding. This started in early July and reached a peak in late July and early August. Numbers of individuals on foliage dropped rapidly after the middle of August. In 1957 and 1959 beetles were scarce after September 1, although in 1958 some were present to around October 1. In a study of losses to soybeans from simulated hail damage Kalton et al. (1) in Iowa described 10 stages of plant growth and found reduction in yields only when foliage was removed as seeds were beginning to develop in the lower pods. This period in general was from July 27 to August 5. Young plants 6 to 12 inches tall and with two to five trifoliate leaves unfolded were injured less, while foliage damaged after the "green bean" stage hastened maturity. They found that the removal of 10 to 75 per cent of the leaves before blooming reduced yields only slightly, while 10, 25, 50, 75 and 100 per cent defoliation during the critical period reduced yields 8, 13, 18, 36 and 83 per cent respectively.

To simulate feeding injury and to determine subsequent losses in yield, soybeans were planted on the Purdue Agronomy farm in 1958 and 1959. Varying amounts of foliage were removed by hand from plots on one up to six dates. The soybeans used in 1958 was Clark, a late maturing variety. Foliage was removed on an eight day schedule and the amount removed was a percentage of the total foliage present on that day. The timing and amounts removed and the subsequent yields are given in Table 1. Maximum feeding activity of the beetle occurred around August 4 in that year, but the plots with 25 per cent of the foliage removed on that date had the highest yields of the experiment. The removal of 50 and 75 per cent of the foliage on this one date caused no significant reduction over the undamaged and the 25 per cent plots. Plots with multiple defoliations, especially when these occurred late into August, had significant reductions in yield as did those plots with 75 per cent defoliation on August 20 and the two plots with 100 per cent on August 4 and 20.

In 1959 the effect of foliage removal was compared with normal and with sprayed plants of Lindarn soybeans. While insects are of little importance on soybeans, leafhoppers and the spotted cucumber beetle were rather abundant this season. The plots sprayed three times with DDT at a rate of one pound actual per acre produced the highest yield of the experiment, but were not significantly better than the normal plants. Plots sprayed with a new phosphate insecticide, Dimethoate, at a rate of one pound actual per acre produced a good yield, but was significantly lower than the DDT plots.

The effect on yield of removing various amounts of foliage is given in Table 2. The amounts of foliage removed were reduced from the

TABLE 1. Yield of Clark soybeans when certain percentages of the total foliage present were removed by hand picking at various stages of growth. Agronomy Farm, 1958

Treatment No.	Dates and Amount of Foliage Removed						Yield per acre
	July 17	July 25	Aug. 4	Aug. 12	Aug. 20	Aug. 27	
	%	%	%	%	%	%	bushels
7.	—	—	25	—	—	—	47.9
20.	—	—	—	—	—	—	46.7
4.	25	—	25	—	—	—	46.6
14.	—	—	—	—	25	—	45.5
1.	25	—	—	—	—	—	44.5
11.	—	—	25	—	25	—	43.7
9.	—	—	75	—	—	—	43.5
2.	50	—	—	—	—	—	43.5
8.	—	—	50	—	—	—	43.2
5.	25	25	25	25	—	—	42.8
6.	—	25	25	25	25	—	40.8
19.	—	—	—	25	25	25	40.7
12.	—	—	25	—	50	—	40.4
13.	—	—	50	—	25	—	40.0
3.	75	—	—	—	—	—	39.7
18.	—	—	25	25	25	25	39.7
15.	—	—	—	—	50	—	37.6
16.	—	—	—	—	75	—	34.8
10.	—	—	100	—	—	—	29.6
17.	—	—	—	—	100	—	23.4
L. S. D.	19 :1						4.2
	99 :1						5.5

TABLE 2. Yield of Lindarn soybeans when some plots were sprayed and others had certain percentages of the foliage present removed by hand picking at various stages of growth. Agronomy Farm, 1959.

Treatment No.	Dates and Amount of Foliage Removed							Yield per acre
	July 9	July 16	July 23	July 30	Aug. 6	Aug. 13	Aug. 20	
	%	%	%	%	%	%	%	bushels
8. DDT Spray[1]	x	—	x	—	— x	—	—	49.1
9. Untreated	—	—	—	—	—	—	—	46.7
10. Dimethoate Spray[2]	x	—	x	—	— x	—	—	45.5
2.	—	10	—	10	—	10	—	45.6
6.	—	—	—	50	—	—	—	45.1
4.	—	25	—	25	—	25	—	43.9
5.	—	—	25	—	25	—	25	43.2
3.	—	—	25	—	25	—	—	42.7
1.	10	10	10	10	10	10	10	42.5
7.	—	—	50	—	50	—	—	38.8
L. S. D.	19 :1							2.8
	99 :1							3.9

[1] DDT at 1 pound actual per acre was applied July 9, 23 and August 10.

[2] Dimethoate applied at 1 pound actual on the same three dates

previous year and consequently few yields were significantly lower than the untreated plots. A 10 per cent removal on three dates caused no appreciable reduction, while 10 per cent removal on seven consecutive weeks did reduce yield. A 50 per cent removal on July 30 caused no reduction, while 50 per cent removal on July 23 and August 6 resulted in a big reduction. In general the removal of foliage on August 6 or later had more influence on yield than did the earlier removal.

The effect of feeding by beetles caged on soybean plants was observed in Newton County in 1958 and 1959. Three cages, 3 feet high, 2½ feet wide and 10 feet long, were placed over soybeans in a commercial field. Beetles were introduced into two cages at various dates starting in late July. One cage was considered "heavy," one "medium" and one "none." In the first year 48 females and 21 males were introduced into the first cage over a period of 18 days. About half this number were placed in the second cage. In the "none" cage at least five were observed, apparently emerging from the soil after the cage was set. Feeding was not extensive in any of the cages, although beetles were seen through September and one was found alive on October 1. Plant growth in the cages was more or less normal, although plants were 10 to 12 inches taller than those outside. Beans harvested from the caged areas were about the same, ranging from 448 to 468 grams.

In 1959 the cages were again placed in a commercial field. In the "heavy" cage 83 females and 86 males were placed and in the "medium" 36 females and 41 males. Little feeding or beetle activity was observed in any of the cages. Yields of beans from caged areas were 515, 517 and 415 grams and from a comparable area outside the cage an average of 669 grams. Although a quarter inch mesh hardware cloth was used on the cage, it was possible that some beetles escaped.

Summary. The Japanese beetle in Newton County showed a definite host preference for the foliage of smartweed, but did become scattered over soybean fields in late July and early August. Beetle populations in the years 1957 and 1959 were low and even in the heaviest infested fields less than one per cent of the foliage showed feeding injury. One exception was an area of 1¼ acres where 12 rows of soybeans were planted as a border along the end of a corn field. Here the beetle count on the outside row was 5 per foot and 2 per foot on the inner row or a total of approximately 36,000 per acre. Damage in the five days before the farmer killed all beetles with a DDT spray was estimated at 10 per cent of the foliage.

Losses caused by beetle feeding were simulated in tests at Lafayette by the hand removal of foliage from soybeans. Plots had 10, 25, 50, 75 and 100 per cent of the foliage removed on one or up to seven different dates. In general 10 and 25 per cent of the foliage could be removed on several dates without reducing the yields. The critical period of growth was from July 28 to about August 8 when the beans were starting to fill the pods. The removal of 10 per cent of the foliage at seven weekly intervals did cause some reduction.

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GEOLOGY AND GEOGRAPHY

Chairman: R. W. LOUNSBURY, Purdue University
JOHN C. HOOK, Indiana State Teachers College, was elected chairman for 1960

ABSTRACTS

The Darrow Mastodon.[1] WILLIAM J. WAYNE, Indiana Geological Survey.—Many individual specimens and fragments of *Mastodon americanus* have been removed from boggy areas of Indiana and adjacent states since the first collections were made at Big Bone Lick about 1739. Even though the bones of these extinct mammals have long attracted attention, little has been published on the geology of the places from which such fossils have been taken.

Part of a mastodon was exposed by dragline in a small peat bog on the Frank Darrow farm near Oliver Lake, LaGrange County, in 1957. When it was removed in August 1959, the sediments and surroundings of the boggy area in which the bones had been preserved were studied in detail.

The surface material in this area is glacial till, but gravel underlies it at a shallow depth. Springs issue from the gravel at many places along the ditch that leads away from the mastodon site. The small bog in which the mastodon bones were discovered was filled with 1.8 meters of olive brown sedge peat containing wood fragments and spruce(?) cones. The lower half of the peat is silty and overlies gray sandy till. The skull lay on a mat of Sphagnum peat that is similar in appearance to a 5 centimeter bed of Sphagnum peat about a half meter above it in the rest of the bog. A pollen diagram of the enclosing sediments shows that spruce was dominant in the forest vegetation while the peat was being deposited. A single dart point was found in the decomposed peat above the Sphagnum layer and probably was not contemporaneous with the mastodon.

Inasmuch as only part of the skeleton was present and the upper side of the skull had weathered away, the bog probably was nearly filled with sediment by the time the animal became mired and died. The Sphagnum beneath the skull may have been carried down from the surface when the head and shoulders sank into the peat, but was strong enough to have supported the rest of the skeleton until it disintegrated. Downward movement of the bones probably was stopped by the higher penetration resistance of the silty peat at a depth of 75 centimeters beneath the surface.

Coal Geology of Gibson, Posey, and Vanderburgh Counties, Indiana.[1] S. A. FRIEDMAN, Indiana Geological Survey.—A preliminary study shows that the rocks of Pennsylvanian age in Gibson, Posey, and Vanderburgh

[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

Counties contain 13 bituminous coal beds. Coals III, V, VI, and VII have been mined commercially from these beds.

Coal V is the thickest and most extensively mined coal; it underlies most of the area and ranges from 4 to 8 feet in thickness. Coal V crops out only in the extreme eastern part of Gibson County. Because of its southwesterly regional dip, it is 160 feet below the surface in southeastern Vanderburgh County, 400 feet in central Gibson County, and 700 feet in southwestern Posey County.

In Gibson and Vanderburgh counties, 25 mines, all but 2 of which have been abandoned, have produced 45 million tons of Coal V and 2 million tons of Coals III, VI, and VII. These two counties still contain 3.4 billion tons of recoverable coal reserves, and Posey County, from which no coal has been produced commercially, contains an additional 2.7 billion tons. Fully a third of the total recoverable coal reserves in Indiana lie in Gibson, Posey, and Vanderburgh Counties. Most of this coal would require underground mining.

Posey County has recently attracted the attention of mining interests that prefer to mine coal in an area that is close to the inexpensive transportation provided by the Ohio River. Mining difficulties would be encountered in this county as well as in western Gibson County and western Vanderburgh County because of faults. High-angle normal and reverse faults in these areas have produced a series of grabens and horsts. The faults apparently have no expression on the present land surface. Any coal company interested in this area would need to locate the exact position of the faults by a series of closely spaced boreholes.

Unusual Mineral Assemblage Associated with Lower Pennsylvanian Conglomerate.[1] JACK A. SUNDERMAN and SEYMOUR S. GREENBERG, Indiana Geological Survey.—Hydrated and dehydrated halloysite, allophane, crandallite, gibbsite, kaolinite, iron oxides and manganese wad occur in an abandoned quarry north of State Road 451, about 1½ miles west of Williams, Lawrence County, Indiana. This unusual combination of minerals is found within the poorly consolidated quartz conglomerate in the Mansfield Formation, which probably lies directly on the Mississippian-Pennsylvanian unconformity.

The halloysite occurs as lenses and as discrete particles up to pebble size, whereas the allophane occurs only in lenses that exhibit columnar and botryoidal structures. The crandallite has formed at the expense of allophane and possibly at the expense of halloysite. Manganese wad occurs both as coatings on quartz pebbles and as lenses up to 2½ inches thick. Most lenses of wad are intimately associated with hydrated halloysite and gibbsite. Very well- to poorly-crystallized kaolinite occurs as discrete particles between quartz pebbles. Iron oxides occur as irregular bands and stainings throughout the quarry.

About 200 yards southwest of the quarry, two layers of well-crystallized barite occur just above a Mississippian limestone. The layers of barite are each half an inch thick and are separated from each other by a half-inch thick layer of iron oxides.

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[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

The Lowly Nonmetallics.[1] DUNCAN J. MCGREGOR, Indiana Geological Survey.—No branch of geologic science has attracted more interest than that of economic geology. Looking back over the past several years one cannot fail to note, however, the unequal attention which the major subdivisions of economic geology, the metals, nonmetals, and fuels have received. The nonmetals rank at the bottom of the list. Probable reasons for this are:

(1) The metallics are worth more per unit weight and possess a stronger attraction than the less glamorous nonmetals, exclusive of the fuels.

(2) Certain principles have been set forth relating to ores as a class which cannot be or has not been done for the nonmetals.

(3) Each nonmetal offers a series of separate and distinct problems which may or may not be applicable to nonmetals in general.

(4) Geology departments of colleges and universities commonly overemphasize the metals in their curriculum, even to the exclusion of courses in nonmetallic minerals.

(5) Solution to the industrial geologic problems of the nonmetals becomes critical only when sudden demand dictates a need for scientific help.

(6) Little geologic research is supported by industry who use the nonmetals. Nor are many industries aware of the importance of a geologist in their organization.

In the study of the use and availability of the nonmetallic minerals, the dividing line between economics and geology is vague. Commonly non-geologic problems such as exploration and exploitation costs, market, transportation, and fuel surveys are the most important items to be considered.

It is suggested that a critical review be made of the nonmetallic minerals in the curriculum of the Geology departments of colleges and universities. More emphasis should be given the economic aspects of the nonmetallics. Students should be made aware that concentrated study in the field of the nonmetallic minerals can be most rewarding both in terms of geologic interests and future employment.

Recent Geologic Work in Antarctica. N. B. AUGHENBAUGH, Purdue University.—The International Geophysical Year opened a new period of geologic exploration in the Antarctic. Previous investigations were confined to the Ross Sea region, Palmer Peninsula and certain accessible coastal areas. Field parties from several nations have made traverses into many parts of the interior. Some of the findings are reported.

A Paleontological Viewpoint on a Poor Misunderstood Ostracode from Indiana.[1] ROBERT H. SHAVER, Indiana Geological Survey.—A review of

[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

the historical and philosophical approaches to the paleontological species recalls that our formal typological method dates from 200 years ago at the time of Linnaeus when species were thought of as discrete entities without relation or gradation to other species. Especially since Darwin's time of about 100 years ago, most paleontologists have accepted the fact of imperceptible time-geographic gradation among species. The practice of the discrete-species approach continues beyond the requirements of the Rules of Nomenclature, and this pours fuel on the controversial fire among paleontologists. The traditional type method and other reasons commonly given for practicing the discrete species are overworked crutches which often do not result in the most useful species.

A study of the Pennsylvanian ostracode *Bairdia oklahomaensis* is presented in defense of above views. Confusion resulting from the traditional approach to *Bairdia* does not permit safe acceptance of any of the numerous concepts of *B. oklahomaensis* except the all-inclusive one. The species therefore is said to range nearly throughout the Pennsylvanian System and to have little or no stratigraphic value.

The triangular graph is used to infer vertical speciation from a progressively gradational series as represented by 12 populations of *B. oklahomaensis* s. l. taken from throughout the vertical and lateral range of the species in Indiana. Among the four names that have been applied to this group, two should continue to be suppressed as synonyms, while *B. oklahomaensis* s. s. and *B. dornickhillensis* are recognized separately with respective ages of post-Atoka and pre-Des Moines. Further refinements in each of their stratigraphic ranges are recognized beyond the limits of practicality of application of new names under the type method.

The triangular graph shows further that geographic speciation apparently did not occur in Indiana within the broader concept of the species and that the considerably different mean sizes among the several populations are of no genetic or taxonomic significance.

A "Fossil" Cave-filling in the St. Louis Limestone in Putnam County, Indiana.[1] GARY R. GATES and NED M. SMITH, Indiana Geological Survey, and WILTON N. MELHORN, Purdue University.—Recent excavations at the Harris quarry in the SE¼NW¼ sec. 15, T. 15 N., R. 4 W., Putnam County, have revealed an unusual example of solution and refilling in the St. Louis Limestone.

In the west wall of the quarry is a mass of poorly crossbedded shale and sandstone containing carbonized wood and other organic fragments of Pennsylvanian age. This fill is at least as thick as the present 15-foot depth of the quarry. The beveled surface of the sandstone-shale fill was covered by 5 to 10 feet of glacial till prior to stripping.

Sandstone or shale fillings in Pennsylvanian stream channels cut into Mississippian rocks are not uncommon in Indiana. In the Harris quarry, the fill does not occupy a stream channel because it has finite boundaries against limestone in all observable directions. The boundaries are steep and irregular. Small, wedge-shaped solution openings extend laterally

[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

along bedding planes, and some of these openings contain unconsolidated, fine-grained sand.

It is suggested that post-St. Louis solution developed a small cavern in limestone. Two possible methods of cavern-filling are postulated. (1) Post-Mississippian erosion removed any younger Mississippian rocks and unroofed the cavern. Submergence beneath a shallow Pennsylvanian sea filled the unroofed cave with sand and shale containing inwashed plant fragments, and subsequent post-Pennsylvanian erosion removed all Pennsylvanian deposits of the area except in the cavern where the fill was protected by surrounding limestone. (2) Cavern collapse, perhaps aided by weight of overlying Pennsylvanian sediments, downdropped a wedge of sand and shale into the cavern, where it was preserved in the same manner suggested in (1). The exact answer to this problem must await exposure of the base of the fill. The unconsolidated sands filling lateral solution openings may be residual cave deposits left by water flowing through the cavern prior to unroofing or collapse, and are therefore older than the cave fill.

This feature is considered a "fossil cave," unrelated to recent and current cavern development in Mississippian limestones in Putnam County and elsewhere in southern Indiana.

Petrology of Sandstones from the Big Clifty Formation of Indiana.[1] SEYMOUR S. GREENBERG, Indiana Geological Survey.—Sandstones from the Big Clifty Formation of late Mississippian age are well to extremely well sorted and have median sizes that range from 0.20 mm. to 0.10 mm. Younger Big Clifty sandstones are finer grained than older Big Clifty sandstones, and the cumulative curves of the former have higher skewness values ($\frac{\text{1st quartile} \times \text{3rd quartile}}{\text{median}^2}$) than those of the latter.

Quartz constitutes 85 to 95 percent of most Big Clifty sandstones; feldspars, clay minerals, and micas each constitute less than 5 percent of these sandstones. The total percentage (by weight) of the heavy minerals (specific gravity greater than 2.95) is less than 0.5. Iron oxides, leucoxene, tourmaline, zircon, brookite, rutile, and apatite are the significant heavy minerals (in decreasing order of abundance).

The immediate source for the Big Clifty sandstones contained abundant reworked sedimentary rocks; igneous and metamorphic rocks provided little detritus in the latest cycle. At the last depositional site, reworking was extensive and burial was slow. Ilmenite was altered to leucoxene in early sedimentation cycles, and brookite grew at the expense of leucoxene in recent cycles. Iron oxides (the chief cement) and quartz overgrowths (a minor cement) were precipitated in the most recent cycles.

Petrology of the Bethel Formation (Lower Chester) in Indiana. GARY E. HENRY and JOHN B. DRUSTE, Indiana University.—Mixed layer minerals and illite are the most abundant clay minerals in the argillaceous Bethel sediments. Lesser amounts of kaolinite are present. The ratio of their relative abundances is 4:4:2. Quartz is the most abundant mineral

[1] Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

in the shales and underclays, but the clay minerals as a group are slightly more plentiful than quartz in the smut steraks. Feldspar, calcite, and dolomite are also present in the argillaceous rocks. A 14Å component ranging from chlorite to vermiculite is present in a few samples. In the arenaceous units kaolinite predominates followed by mixed layers and illite. Their ratios are 5:2½:2.

The sandstones are well-sorted and orthoquartzose. Heavy minerals are leucoxene, magnetite-ilmenite and zircon in abundance, and minor amounts of garnet, tourmaline, rutile, iron oxides, pyrite, and muscovite. Quartz is the dominant light mineral; chert, potassium feldspar, and plagioclase occur in very small amounts. The limestones in the formation are clastic and fossiliferous.

The depositional environment probably varied from slightly brackish to normal marine waters; local accumulations of coal represent nonmarine deposition. The heavy minerals in the sandstones indicate that they are reworked sediments.

The clay minerals are largely products of their diagenetic environments rather than of their source areas. The kaolinite is considered partly detrital, but circulating acid ground-water probably provided a favorable environment for forming kaolinite diagenetically. Illite apparently formed from "degraded illite" through adsorption of potassium ions. Mixed layers are considered to have formed by montmorillonite and/or degraded illite adsorbing potassium and magnesium ions upon entering the marine environment.

Some Engineering Problems Associated with the Preglacial Marietta River Valley. K. B. WOODS, Purdue University.—During the course of an engineering investigation of the soil conditions in the valley floor and adjacent tributaries of the preglacial Marietta River in the general vicinity of Jackson, Ohio, several important problems were encountered. This paper covers a short review of the geological literature on the preglacial Teays River and the Marietta River tributary, together with a report on the engineering characteristics of the foundation materials at several sites in the Marietta River Valley both above and below Jackson, Ohio. It is concluded not only that geologic information can be used as a basis for planning engineering investigations but also that engineering data can be used in many instances to detail or even modify geologic concepts. The need for both geologic information and engineering investigations for design purposes is emphasized in certain situations.

The Forces Which Shift the Earth's Crust. J. A. REEVES, West Terre Haute.—In the 1890's I worked in my father's lead and zinc mines in Joplin, Mo., during vacations. The lead and zinc ore was imbedded in hard flint rock which had been vulcanized millions of years ago by molten lava rising from deep in the earth. This layer of flint rock was over 700 feet thick and was laid down millions of years ago at the bottom of a shallow sea which covered the country. The hot lava melted the limestone and also raised the entire Ozark Range out of the sea to 700 feet above. Natural curiosity helped in seeking ways of explaining this act of nature. All available books on Geology were read and it was learned that all mountain ranges are formed the same way. A dozen or more of the

world's geologists advocated the "migration of the poles." This theory utilized the only gigantic source of power that was required to lift our mountain ranges to their present heights and lower others. Details of the many forces which rotate the earth's crust on its plastic center in the north-south direction are given and shows how the shifting of the earth's crust raises some of the mountain ranges and lowers others.

The Parrish and Glasford Mastodons[1]

Wilton N. Melhorn, Purdue University

Introduction

Remains of the American mastodon, *Mammut americanum*, are relatively common in Indiana, ranging from finds of a single tooth or bone to nearly complete specimens. This latter group was excavated mostly prior to 1910 and no significant discoveries have been reported in recent years. A catalogue of all known Indiana occurrences of the mastodon and the true elephants was compiled in 1912 by Hay (1). During the last 40 years other remains have come to light and have been reported in the proceedings of this academy or merely as news items in local newspapers.

Two newly-discovered mastodons were examined during May 1959. These examinations aroused the writer's interest and led him to investigate the literature concerning the past discovery and disposal of our mastodon remains. It was interesting but also greatly disappointing to find that although Indiana has exported complete or nearly complete specimens to most major museums in the United States, only one mounted specimen has been kept for permanent display within the state (3).

Parrish Mastodon

Ditching operations for a watershed management program exposed a skeleton near the northern margin of a 20-acre peat bog on the Richard Parrish and Glen Slater farms in the NW¼ SW¼ section 32, T. 29N., R. 1E., Fulton County. The location is on gently rolling ground moraine containing sphagnum- and peat-filled depressions that probably were occupied originally by shallow lakes. The Maxinkuckee moraine is about 2 miles east of this bog.

The bones were excellently preserved, although the pelvis had been broken by the dragline. The sacrum and rear leg bones had been removed from the ditch and exposed to air for more than a week, but treatment with white shellac and alcohol prevented any excessive crumbling or cracking. Excavation proceeded headwards from the pelvic bones which still protruded from the bank of the ditch. Much of the posterior two-thirds of the skeleton was recovered, including 23 ribs and their attendant dorsal vertebrae, the lumbar vertebrae, the sacrum, rear legs, and toe bones. The patellae and 18 caudal bones were recovered also. The cervical vertebrae, skull, tusks, and the greater part of the sternum have not been located.

The skeleton was canted downward at a sharp angle into the bog. The bones were buried in an olive-green, macerated peat underlain by a few inches of gray clay. Fine-grained sand underlies the clay at a depth of 5 to 7 feet. The skeleton was disarranged considerably, but no teeth marks of carnivores were visible nor were any artifacts recovered. Similar disarrangement and disarticulation of other skeletons has been reported

[1] Robert C. Parks, Geologic Technician at Purdue University, assisted in excavation, preservation, and assembly of the Parrish mastodon. Dr. Robert Krebs, Virginia Polytechnic Institute, X-rayed soil samples from this site.

previously (2, 4, 5). Position of the pelvis, the first part excavated, suggested that the animal was lying on its side; however, the lumbar and dorsal vertebrae and ribs were in an inverted or "bottoms-up" position. It is believed that the missing portions of the skeleton either are a greater distance away than would be expected normally or have sunk to a greater depth in the bog.

The bones were measured for comparison with other well-known mastodons. Table 1 matches these measurements against similar data available for specimens preserved at the U. S. National Museum.

TABLE 1. Measurements of mastodon bones in mm.

Bone measurement	U. S. National Museum	Parrish
Length of longest rib	1063	1341
Length of femur	930–970*	1073
Average length of dorsals	56–70*	97
Length of sacrum	400	487
Length of 3rd dorsal spine	381	442
Average width of dorsals	125	167

* More than one specimen.

Measurements of the Parrish mastodon average about 20 percent greater than the U. S. National Museum specimens. The largest rib of the Parrish mastodon compares favorably in length with the Warren mastodon (1390 mm), and the femur is about the same size as reported for the Orleton Farms mastodon (1067 mm) and Denver mastodon (1070 mm).

Fusion of the ilium, ischium, and pubis is nearly complete, indicating that the Parrish mastodon was an adult animal, perhaps of somewhat greater than average size.

Glasford Mastodon

Another mastodon was exposed on the Willis Glasford farm in the SE¼ SW¼ section 29, T. 29N., R. 4E., Miami County, where Weasau Creek transects the Packerton moraine. Spring floods caused caving of the creek bank and exposed the anterior part of the skeleton. A lower jawbone containing 4 teeth and an individual upper molar were recovered from the creek bottom. Preliminary excavation uncovered the cervical vertebrae and a portion of the sternum, but the bones were highly decomposed and fragmented quickly when exposed to air. Initial permission for further excavation was later revoked by Mr. Glasford. It is doubtful, however, that this skeleton is worth salvaging even if complete.

The bones lie immediately beneath 4 to 5 feet of fine-grained, pebbly sand and are embedded in what appears to be a reworked glacial till into which the bones perhaps sank after being covered by the sand. The Packerton moraine in this area has a great number of moderate-sized, peat-filled depressions or kettles which may contain better preserved specimens. The Glasford mastodon may be located in the same general area as the Cover mastodon reported by Kintner (2).

Conditions of Preservation

The Parrish mastodon owes its fine preservation to burial beneath 4 to 7 feet of peat in an extensive bog where the water table is only 1 to 2

feet below ground surface. Conversely, the Glasford mastodon lies beneath well-drained sand and is above the level of adjacent Weasau Creek, so that the local water table is below the remains. The bones are within the zone of aeration and are in an advanced stage of decomposition.

Chances of mastodon preservation are enhanced wherever the water table has remained near the surface. Undrained or poorly drained peat bogs or kettle fillings in moraines offer the best prospects for finding well-preserved, complete specimens. Many skeletal fragments have been reported previously from beneath till or in outwash sands, but are commonly in poor condition. In such cases, the water table normally lies below the level of the remains and decomposition has destroyed the bones except for the most resistant parts such as the teeth and skull.

Stratigraphy

A layer of whitish, silt-like material several centimeters thick immediately overlaid the bones of the Parrish mastodon, but was not present a few yards distant from the remains. It was found subsequently that a lens of similar material was present above the Glasford mastodon. X-ray analysis showed that it consists of a mixture of clay minerals and some form of fatty organic residue. Although chemical analysis is lacking, it is tentatively suggested that the residue may be some stable product of decomposition of mastodon tissue.

The underclay at the Parrish site consists of 14Å clay minerals, probably a hydrous (expanded) mica such as vermiculite, and an appreciable amount of 10Å illite and some kaolinite. The silt lens contains mostly illite and kaolinite. This is surprising as some montmorillonite should be present under the reducing environment present in the bog.

The stratigraphy, mineralogy, and palynology of mastodon sites have not been studied adequately, nor was time available to do so in either case herein described. Future discoveries should be examined carefully to determine if the same combination of organic residue and clay minerals is present.

Future Discoveries

Fossil elephant remains are common in Indiana and others will be found in the future as new watershed and land management programs are initiated. Shallow tiles will be replaced by deep ditches to obtain better drainage of bogs and other depressions. A plea is entered for Indiana geologists to inform county agricultural agents and workers in the soil conservation, soils mapping, and watershed management programs that further discoveries may be anticipated. These people have close contact with land owners and are most likely to learn of new finds. If discoveries are quickly brought to a geologist's attention, sites can be examined to determine if recovery is feasible or warranted. The hairy mammoth is represented from Indiana only by the famous Grant County specimen and fragmentary collections of teeth or bones, and *Elephas columbi* is known only in fragmentary form. It is possible that good specimens of both forms will be recovered eventually if good contacts are maintained with local conservationists and soils workers at the county or district level.

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Conversion of Percentage Distributions to Weighted Index Numbers of Geographic Significance

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This paper is essentially a progress report concerning techniques for geographic manipulation of total percentage distributions. Although the percentage distribution here used for illustrative purposes is the age composition of the total population of Indiana counties in 1950, this is but one of many percentage distributions in which geographers have been or might be interested. The Census of Population alone, for instance, provides data on age by color and sex, on school enrollment and years of school completed, on residence, and on the employment status, occupation group, and industry group of the labor force, both for cities and for counties. Similarly, one may obtain data on housing conditions, or on major types of land use, and these are but a few of the types of percentage distributions which might interest geographers.

Our primary problem in utilization of such data is the cumbersome nature of existing techniques for their manipulation. Geographic analysis of these data has thus far been relatively unsophisticated; most commonly a single category from a single percentage distribution is selected for comparison either with other categories from the same distribution, or with selected categories from other distributions, but we have had few comparisons of two entire percentage distributions such as, for instance, an analysis of the relationship between variations, at the county level, of the age-sex distribution and the industry group distribution.

This problem can best be demonstrated by specific illustrations of the techniques which geographers have used in analyzing percentage distributions. It is no lack of modesty, but rather a desire to avoid even the appearance of criticizing others, that has prompted me to draw all these illustrations from my own efforts in this direction.

The simplest technique of analyzing the geography of any percentage distribution is to map each of its individual components. In considering land use patterns in Indiana, for instance, one may shade all counties falling within a certain percentage range with respect to each category (1). Each of these maps can be compared with any other map, of course, but this would necessitate a tedious, cumbersome, and usually highly subjective analysis.

The same objections apply, perhaps with even greater force, to the use of pie diagrams. One obtains a vivid graphic representation, to be sure, when the percentage of the manufacturing force engaged in the textile industry of the Carolina Textile Belt is shown in a pie graph, but it is almost entirely graphic (2). Further comparison with other distributions is extremely difficult, if indeed, it is possible at all.

Our concern with the use of such single categories might be considerably less were they not the basis for most of our functional classifications of urban places (3). Although these classifications purport to indicate the urban function, in the majority of instances they are based almost entirely upon the superabundance of a single occupational or

industrial category, and completely ignore lesser variations within the employment structure. In my functional classification of southern cities, for instance, there are four cities—El Paso, Tex., St. Augustine, Fla., Huntington, W. Va., and Bluefield, W. Va.—which are classified as transportation and communication centers because at least fourteen percent of the employed labor force in each is engaged in these industry groups. Yet the percentage engaged in mining, for instance, ranges from nil in St. Augustine to 0.5 in El Paso, 0.8 in Huntington, and 6.8 in Bluefield, and the percentage engaged in manufacturing varies from 5.2 in St. Augustine to 8.3 in Bluefield, 11.8 in El Paso, and 26.5 in Huntington.

It is variations such as these that have so often frustrated attempts at rational classification of urban function on the basis of employment data, and several attempts have been made to utilize the entire urban industrial structure rather than a single category. We have two techniques, the pie diagram and the columnar diagram—with variants—for portraying entire percentage distributions.

The pie diagram is most impressive, and it conveys a great amount of information within a relatively restricted space (1). But how useful is it for comparative purposes? One can examine the map of major land uses in Indiana, for instance, and see that there is considerable variation in acreage of cropland from one county to another, but it is virtually impossible to make any but the most subjective comparisons between counties in different parts of the state.

A similar objection can be raised to the columnar diagram, even when the columns are arranged in the formal rhythm of the age-sex pyramid (4). The map showing age-sex pyramids for each county in Indiana is quite an impressive sight, but it actually tells us relatively little. One can entertain himself mightily, of course, in examining the pyramids for the various counties and exclaiming over their vagaries, but it is difficult to compare one county with another, even when they are adjacent, and any comparison between the overall pattern of this distribution and any other distribution would appear beyond the ability of mere human beings. In other words, the map is an end in itself rather than a tool for further analysis.

The failure of the age-sex pyramid map as an analytical tool, in fact, prompted a retrogression to the mapping of single categories within the age-sex distribution, in the hope of obtaining new insight into variations in the percentage distributions of the population between the various quinquennial age-sex categories (Fig. 1). But the 1950 Census of Population provides data for seventeen separate quinquennial categories, and as it became obvious that the number was too great for ready comprehension they were grouped into four major categories in terms of demographic potential.

People under 20 may be considered children, and as a general rule they are not producing significant numbers of offspring. Counties with high percentages of children are most numerous in southern Indiana, and in the northwestern part of the state; there are relatively few counties in which children comprise less than a third of the population.

The years 20-44 are the child-bearing ages, and these are also the working years and the migrating years. The counties with the highest

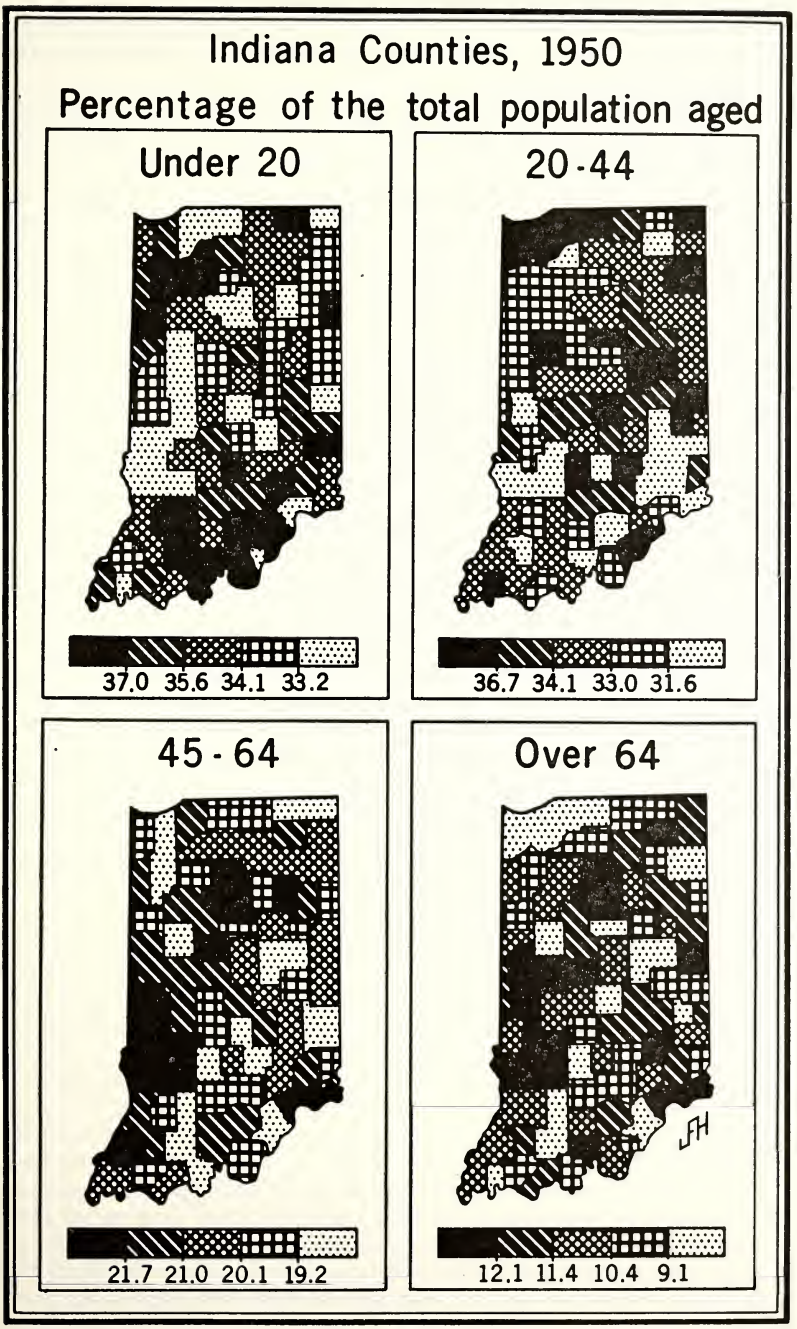

Figure 1. Percentage of the total population, 1950, in each of four age groups, by counties. The class intervals in each age group are based on quintiles.

percentages of their population in this age group are the urban counties, and they are noticeably concentrated in the center of the state and in the northern tier of counties.

The years 45-64 are the middle ages, and the people in this age group are normally past the child-bearing stage of life. Unusually large concentrations of people in this age group may indicate economic stagnation, as in the coal mining areas of western Indiana; the younger people have left, but the middle aged hang on to their homes and familiar associations. A population with a high percentage of its people over 45 is not only an aging population, but it is a dying one, because so many of its people are past the age when they could produce the children needed to maintain the population.

Despite the increasingly pejorative connotations of, and the numerous new euphemisms for the term, "old age" is commonly applied to the year over 64. Unlike the middle aged, a considerable percentage of the old population are no longer part of the labor force, and many of them have retired to areas away from those in which they were once employed. Their distributional pattern is complex, although they are least numerous, per capita, in urban areas.

This last observation, when coupled with the observation that persons in the 20-44 age group are noticeably concentrated in urban areas, can lead us to a useful generalization. Any percentage distribution may be likened to a closed hydraulic system; if it is pressed at one place it will expand at another. And so with the age distribution, or any other percentage distribution; a high percentage in one category will leave fewer people for the remaining categories, and all categories are intimately inter-related in that they must add up to one hundred percent.

Then why not, it might be argued, assign a distinctive weight to each category, multiply the percentage figure for the category by its weight, and total the products to obtain a weighted index for the distribution? It is impossible for two differing percentage distributions to have the same weighted index number, and a single number representing the entire distribution would facilitate comparison with other percentage distributions, or with any other distribution.

The possibilities are intriguing, and I personally believe that the use of properly weighted index numbers is destined to become an increasingly important tool of geographic analysis. Before such numbers can be used effectively, however, we require more information as to the best system of assigning weights to individual categories. It would be possible, of course, to assign each category a distinctive weight at random, and this would produce distinctive and unique index numbers; for instance, we could assign a weight of 1 to percentage aged under 20, 2 to percentage aged 20-44, 3 to percentage aged 45-64, and 4 to percentage aged over 64.

The usefulness of index numbers obtained by such a random weighting system would be inhibited, however, by the fact that they would vary without meaningful pattern. It would be preferable to assign weights so that all counties with low index numbers would be relatively similar to each other, and quite different from the counties with high index numbers; counties with intermediate numbers, of course, would be transitional between these two extremes.

McIntosh demonstrates that this actually can be done with some plant communities (5). He marked individual celluloid strips with the percentage of black oak, white oak, red oak, and sugar maple in each of a number of different stands. When he arranged the strips in order of decreasing black oak and increasing sugar maple, he found that both white oak and red oak peaked at distinctive intermediate points, and he was able to assign each species a weight which had meaning in terms of the inherent character of each stand. A stand dominated by black oak, for instance, had a low weighted index number, whereas a sugar maple stand had a high weighted index, and stands dominated by white and red oak had intermediate indices. These weighted indices proved a useful tool in investigating the relationship between plant associations and soil acidity, in the study cited.

This method of assigning weights to individual categories appeared so promising that it was used in an attempt to assign weights to individual age groups in Indiana (Fig. 2). The counties were ranked in order of increasing percentage of the group aged 20-44, and each of the other three age groups in the county is indicated by a dot at the appropriate percentage. The resulting pattern obviously is not so simple as that found by McIntosh, and a considerable degree of subjective interpretation is necessary. It would appear, for instance, that the percentage of aged people decreases as the percentage aged 20-44 increases, and a similar but slighter decrease is noticeable in the 45-64 age group. It would be a brave man indeed, however, who would attempt to assign weights to individual age groups on the basis of this graph, and hence it has been regretfully laid aside, at least temporarily, because it requires excessive subjective interpretation. Casual observation, however, has indicated that this technique might prove much more useful, and rather less subjective, if quinquennial age groups were used in place of those shown here. There appear to be some interesting relations between quinquennial age groups spaced at twenty-year intervals—or a generation apart—but my investigations along this line have not yet progressed to the point that a formal report is justified.

A second technique of assigning weights, which was used by Hagood in devising her rural level of living index, would appear to merit consideration by geographers. She selected a comparatively large number of characteristics of rural population and housing, and correlated each characteristic with every other (6). The resulting table of correlations shows that some characteristics are so closely allied that either may be used, and the table also provides a basis for weighting the characteristics which are combined in the rural level of living index.

TABLE I

Coefficients of Correlation between the Percentages of the Population in each of four age groups, Indiana counties, 1950

	Group aged		
Group aged	Under 20	20-44	45-64
20-44	0.66		
45-64	0.75	0.71	
Over 64	0.72	0.75	0.79

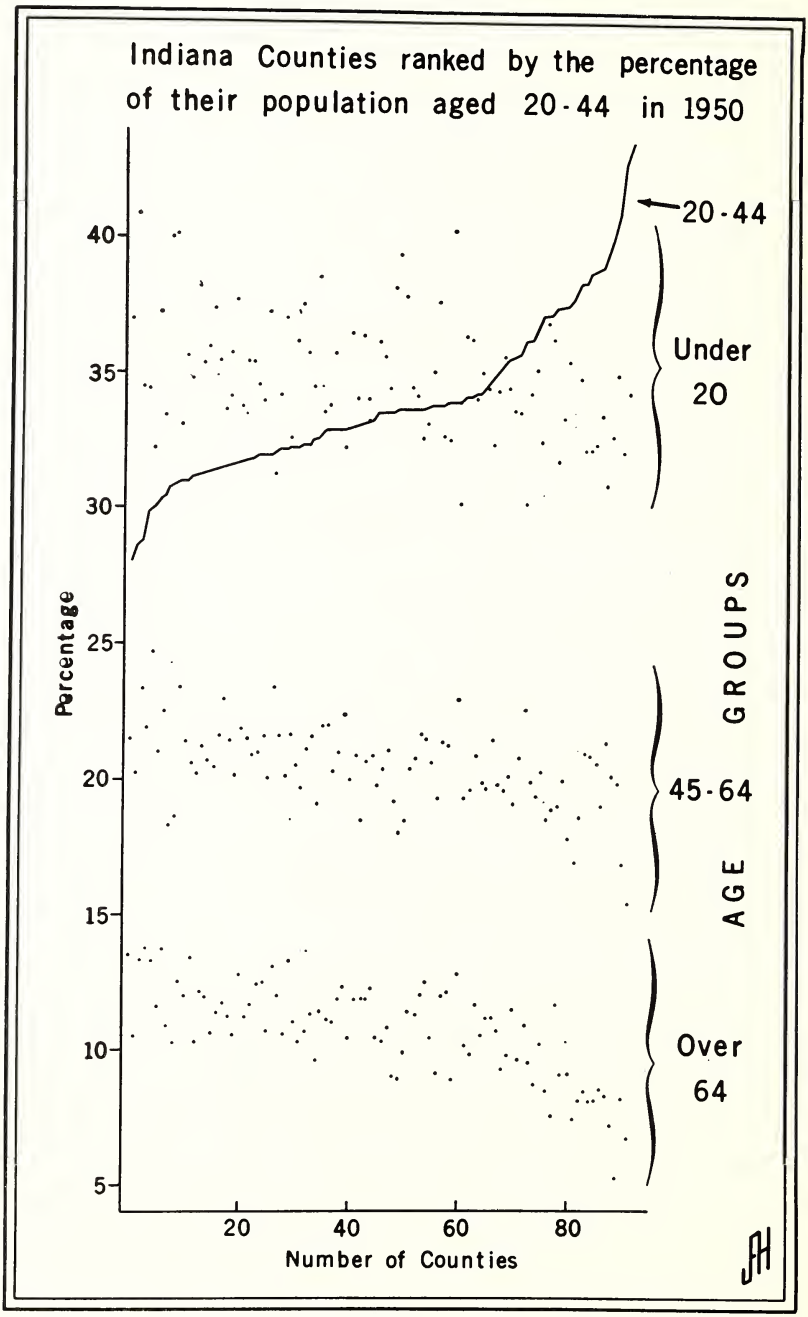

Figure 2. Distribution of the population of Indiana counties in three age groups when the counties are ranked in order of increasing percentage in the age group 20-44.

In an extremely restricted sense I have tried to apply her technique to the age structure of Indiana's population in 1950. I used only four age groups, instead of the seventeen for which data are available, and within each age group I divided the counties into quintiles by percentage so that coefficients of correlation could be computed by the simple method explained by Freund (7). There was a relatively high degree of correlation, possibly because of the restrictions imposed by the method of computation. The closest correlation was between the 45-64's and the over 64's, whose coefficient was 0.79; at the other end of the scale the coefficient between the under 20's and the 20-44's was only 0.66 (Table I).

But here again it seems that more fruitful results would have come from use of all available age groups, with absolute percentages rather than quintile groups. The major obstacle, of course, would be the cumbersome nature of the calculations necessitated, for 136 coefficients of correlation would have had to be computed. It does seem to me that the potential results would appear to warrant these calculations, although I believe that it would be extremely helpful, if not mandatory, to have mass data processing equipment available. If the job is undertaken, I would further suggest that it be done for a representative sample of all counties in the United States, rather than for Indiana counties alone. Hagood, for instance, devised her weights on the basis of a sample of 200 counties, little more than double the number in Indiana.

I do believe that the correlation of each quinquennial age group with every other for such a sample would reveal that some age groups are so closely related that they might be used interchangeably in an index of age structure, and that relations between other groups are such that they might be weighted to provide a rationally weighted index of the age structure of any unit of area. This index, being a single number, could then be used for further comparison and correlation with other data, whether statistically or cartographically. And I believe that a series of such indices, for the various sorts of percentage distributions cited at the beginning of this paper, would enable geographers to obtain new insight into unsuspected relationships between percentage distributions.

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Land Use Changes Caused by a Quarter Century of Strip Coal Mining in Indiana

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Strip coal mining production records for Indiana are complete since 1917, but only during the last 25 years have more than 40 per cent of Indiana's total coal production been derived from strip mining. From 1934 to date, the annual output from strip mining has exceeded 6 million tons (1). In recent years strip mining has produced from 3/4 to 4/5ths of all Indiana's coal output, and there are only six active underground coal mines left in Indiana.

Strip coal mining has taken place within 15 counties of Southwestern Indiana. Fifty strip mines are actively at work in Indiana but 4/5th of the current strip mine coal tonnage is produced in Warrick, Vigo, Pike, and Greene Counties (2). Most of the remaining 1/5th of strip coal tonnage occurs in Knox, Sullivan, Clay, Gibson, Owen, and Vermillion Counties.

No survey has been made of the areal extent of strip coal mining in Indiana except for G. A. Linstrom's article entitled "Extent, Character and Forestation Possibilities of Land Stripped for Coal in the Central States" published in 1948 by the Central States Forest Service (3). No recent measurements of the extent and land use impacts of strip coal mining have been made in Indiana. With the aid of a research grant from RESOURCES FOR THE FUTURE, the writer here presents a brief

LAND USE (ACREAGE)

COUNTY	LAND STRIP MINED	FORMER CROPLAND	TREES ON SPOILS	GRASSES & LEGUMES ON SPOILS	AREAS USED FOR RECREATION	IDLE SPOILS
CLAY	18,295	14,015	17,280	250	1,900	660
GREENE	18,200	5,200	5,725	2,925	3,800	0
PIKE	16,104	7,604	3,385	0	333	12,485
WARRICK	13,265	5,682	9,949	0	260	3,316
SULLIVAN	8,303	3,669	5,800	200	2,430	783
VIGO	7,727	6,305	3,500	525	5,530	1,670
KNOX	2,825	2,525	325	350	70	1,775
OWEN	2,690	1,850	1,550	100	1,100	1,140
VERMILLION	2,340	800	1,660	0	1,200	1,140
DAVIESS	2,218	1,915	1,450	0	1,400	720
SPENCER	890	440	280	0	280	550
PARKE	443	180	210	0	21	227
FOUNTAIN	380	310	300	0	0	60
OTHERS	156	0	156	0	0	0
TOTAL	93,836	50,495	51,363	4,350	18,324	24,685
% OF TOTAL	100%	53.8%	54.7%	4.6%	19.5%	26.3%

Figure 1

summary of recently compiled data on the extent of strip coal mining and of selected aspects of impacts upon agricultural land use in Indiana.

From measurements of aerial photos and topographic maps; estimates from Soil Conservation Technicians and County Agricultural Agents; and coal data from the files of the Indiana Coal Association, the total acreage of land strip mined for coal in Indiana is 93,836 acres (Fig. 1). In 1947, the Central States Forest Service measured 41,909 acres strip mined in Indiana. This represents a 233 per cent increase in strip mined acreage during the last 12 years.

Four counties have more than 10,000 acres of spoil banks (Fig. 2). About 70 per cent of all Indiana's spoil banks occur in four counties; Clay, Greene, Pike, and Warrick Counties have a total of 65,865 acres of spoil banks. Vigo and Sullivan Counties have another 16,130 acres and account for 17 per cent more of Indiana's spoils. Vermillion, Owen, Knox, and Daviess each have from 1,000 to 5,000 acres. Fountain, Parke, Martin, Gibson, and Spencer Counties complete the areal extent of spoil banks each with less than 1,000 acres of strip mine acreage. Since Linstrom's 1947 survey, Greene County has more than trebled in strip mine acreage; Clay and Warrick Counties have more than doubled, and Pike County has experienced a 50 per cent increase in spoil bank acreage. These four counties also contain the greatest estimated strippable coal reserves. According to a recent survey, 2,698,345,000 short tons of strippable coal remain in the six county area within which more than 5,000 acres of spoil banks are located (4). It appears that the large areas of strip coal mining in Indiana will grow larger and the others will become proportionally smaller. Clay County Soil Conservation officials estimate that 26,865 acres of strip mined lands will occur in Clay County by 1975. Therefore, in the future, the areal pattern depicted now will probably remain much the same; only the figures will change.

Of the 50,495 acres of cropland which have been stripped for coal, Clay County has lost 14,015 acres. Vigo, Greene, Pike, and Warrick Counties each have had from 5,000 to 10,000 acres of cropland stripped (Fig. 3). In all five of these counties significant sized farming areas have been taken over by mining operations. Since most of the land which was stripped has provided the owner with as much income from the recovered coal as it would have from agriculture for a decade or more, many owners have not hesitated about selling their cropland for strip mining. Some cropland has been strip mined in all the 13 major coal-producing counties.

In 1941, Indiana passed the first law in the United States which required the reclamation of all strip mined areas (5). Ten years later amendments to the original law were passed to include information secured during the 1941 to 1951 period. All reclamation is carried out under the administration of the State Forester's office.

Tree planting has been the most widespread method of spoil bank reclamation. Of the 51,374 acres of tree plantings on Indiana's spoils, about 50 per cent has been planted with such native deciduous species as sycamore, cottonwood, tulip poplar, ash, red oak, sweet gum, and soft maple. The other one-half consists mostly of White, Norway, Jack, Pitch and Virginia Pines. Clay County, with 18,295 acres in spoil banks, is the only county to have more than 10,000 acres of tree plantings (Fig. 4).

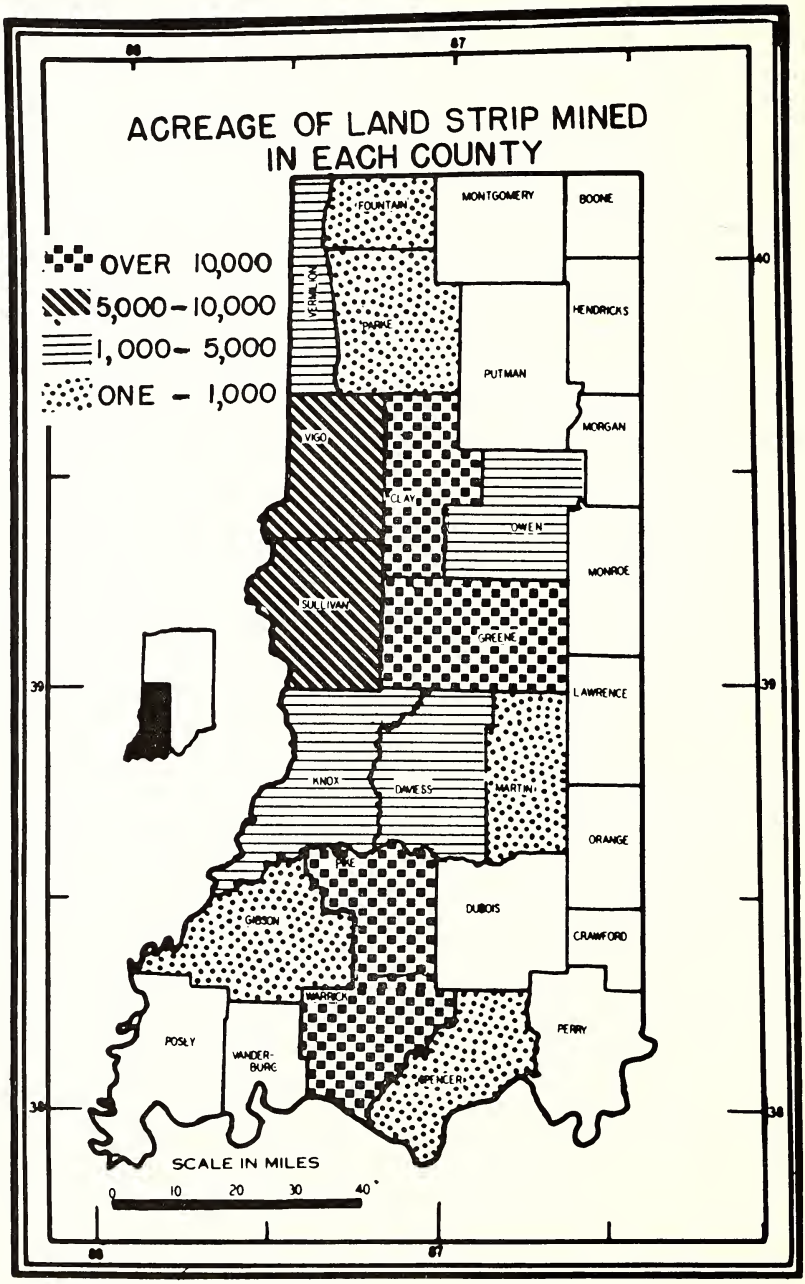
ACREAGE OF LAND STRIP MINED
IN EACH COUNTY
OVER 10,000
5,000 - 10,000
1,000 - 5,000
ONE - 1,000
FOUNTAIN
MONTGOMERY
BOONE
VERMILLION
PARKE
HENDRICKS
PUTNAM
MORGAN
VIGO
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
KNOX
DAVIESS
MARTIN
ORANGE
PIKE
DUBOIS
GIBSON
CRAWFORD
WARRICK
POSEY
VANDER-
BURG
SPENCER
PERRY
SCALE IN MILES
0 10 20 30 40
87
88
40
39
38

Figure 2

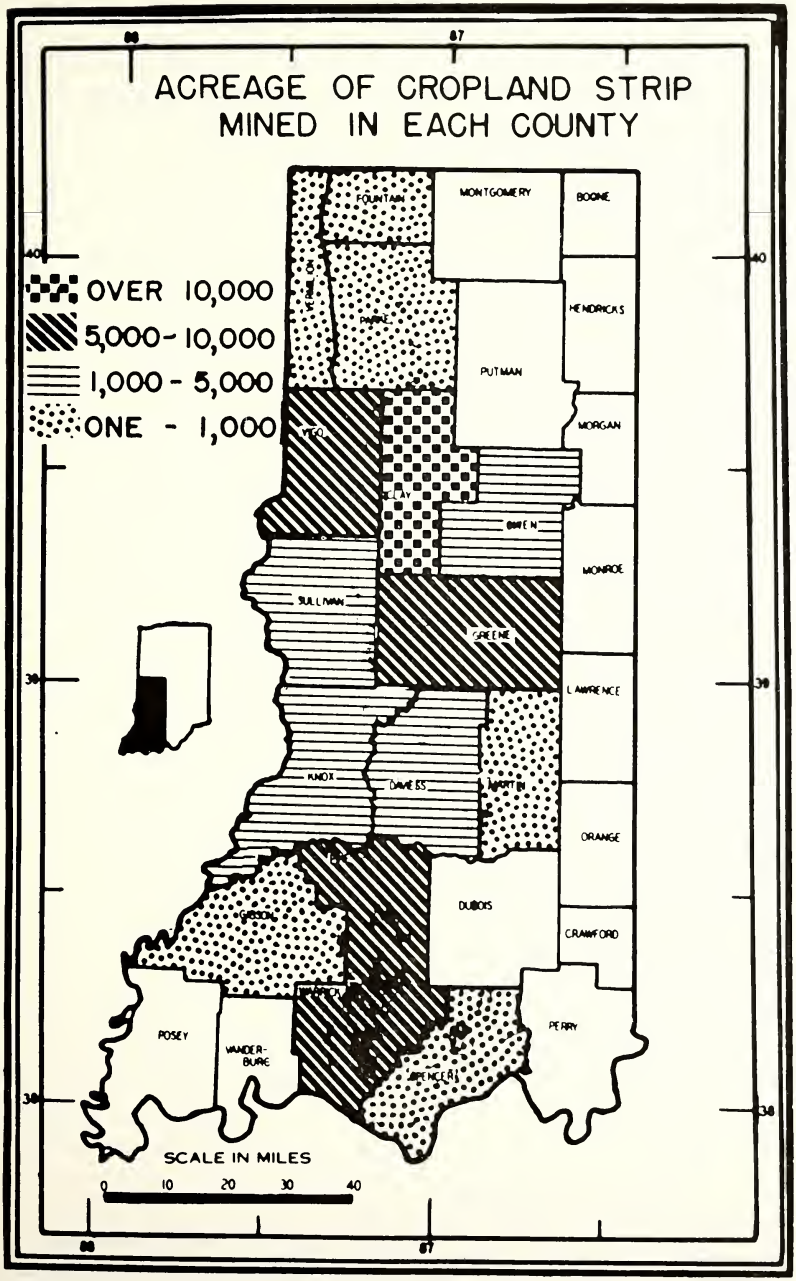
ACREAGE OF CROPLAND STRIP MINED IN EACH COUNTY
OVER 10,000
5,000 - 10,000
1,000 - 5,000
ONE - 1,000
FOUNTAIN
MONTGOMERY
BOONE
PARKE
PUTNAM
HENDRICKS
MORGAN
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
KNOX
DAVIESS
MARTIN
ORANGE
GIBSON
DUBOIS
CRAWFORD
POSEY
VANDER-BURG
WARRICK
SPENCER
PERRY
SCALE IN MILES
0 10 20 30 40
88
87
40
39
38

Figure 3

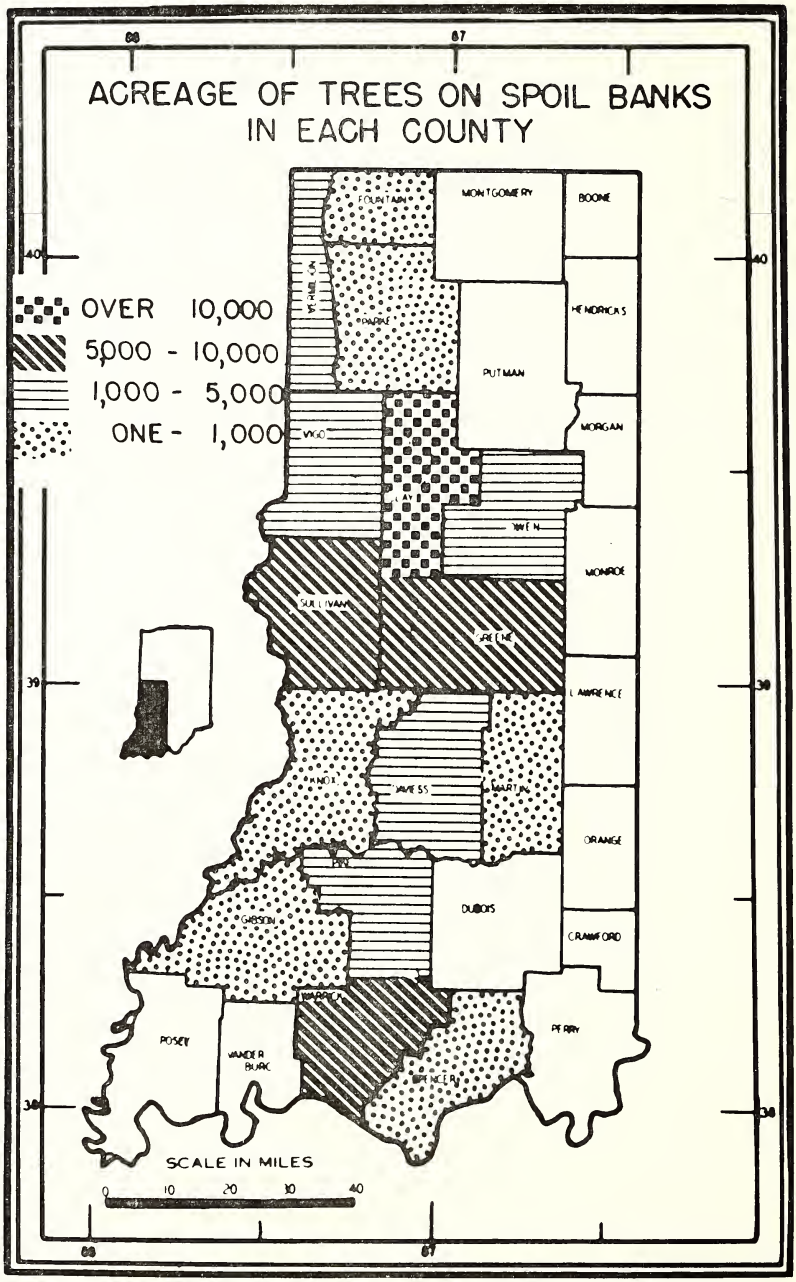
ACREAGE OF TREES ON SPOIL BANKS
IN EACH COUNTY
OVER 10,000
5,000 - 10,000
1,000 - 5,000
ONE - 1,000
MONTGOMERY
BOONE
HENDRICKS
PUTNAM
MORGAN
MONROE
LAWRENCE
ORANGE
DUBOIS
CRAWFORD
PERRY
SPENCER
WARRICK
POSEY
VANDERBURG
GIBSON
PIKE
DAVIESS
MARTIN
SULLIVAN
GREENE
VIGO
CLAY
OWEN
PARKE
FOUNTAIN
SCALE IN MILES
0 10 20 30 40
88
87
40
39
38

Figure 4

Greene, Sullivan, and Warrick Counties are the only other three counties to have more than 5,000 acres of trees planted on spoil banks.

Tree plantings usually cost less than other types of reclamation; they hide the unsightly banks quickly since they grow rapidly. They often provide an attractive cover, but to date they have had little marketable value, and reforestation is slow (6).

Grasses and legumes have been sowed on about 5 per cent of Indiana's spoil banks. Greene County, with 2,925 acres, contains more than one-half of all the state's spoils revegetated with grasses and legumes. Vigo, Clay, Owen, and Sullivan Counties make up the remainder of the 4,350 acres in grasses and legumes (Fig. 5). None of the southern counties have spoil material suited to the growing of grasses and legumes. The opportunities for successful reclamation by sowing grasses and legumes are greater in the glacial till areas.

The soft shales of Greene, Vigo, Clay, Owen, and Sullivan Counties are also characterized by a higher pH reaction than the massive sandstones of the southern mining areas. In addition, there are usually more than one-half of the surface material with a diameter of less than .002 mm.

One large mining company has established a corporation called Meadowlark Farms, Inc., where spoils containing an abundance of calcareous material from glacial till are used for profitable grazing of hogs and beef cattle from sowed alfalfa and sweet clover. This same mining company also mines land in Pike County where they have acid, rocky sandstone spoil material. They are convinced that forestation is the most feasible use of their Pike County lands.

According to accumulated estimates from County Agricultural Agents and Soil Conservation Service personnel, 18,324 acres of strip mined lands have been developed or used as recreational areas in Indiana. Although this represents only 19.5 per cent of the total acreage, these areas represent a great asset from the standpoint of public utilization of strip mined lands. Vigo and Greene Counties have each more than 3,000 acres where private interests, sportsmen's clubs, and other individuals or groups have home or cabin sites and have developed recreational facilities from strip mined lands. Scales Lake State Park in Warrick County near Boonville is one example of a public recreational area and fish hatchery which have been developed from spoil banks.

Inasmuch as quail and cottontails are normally numerous on spoil banks with a good ground cover, an undetermined amount of strip mined land is used for hunting. Swimming, bluegill and bass fishing are common in strip mine lakes which are deep, long, and narrow resulting from the last box-cut. Smaller, shallower ponds created where the water table has risen above the bottoms of the valleys between strip mine ridges provide desirable environments for furbearing animals and waterfowl. Thus, from swimming, hunting, fishing, and trapping, strip mine lands are viewed as areas providing unlimited recreational opportunities.

The proximity to urban areas is a major factor in the location of recreational areas. Vigo, Greene, Vermillion, Sullivan, Clay, Owen, and Daviess are the counties within which more than 1,000 acres is considered recreational (Fig. 6). Southern counties are often inaccessible because of rugged terrain which most sportsmen find too difficult to hunt, fish, or

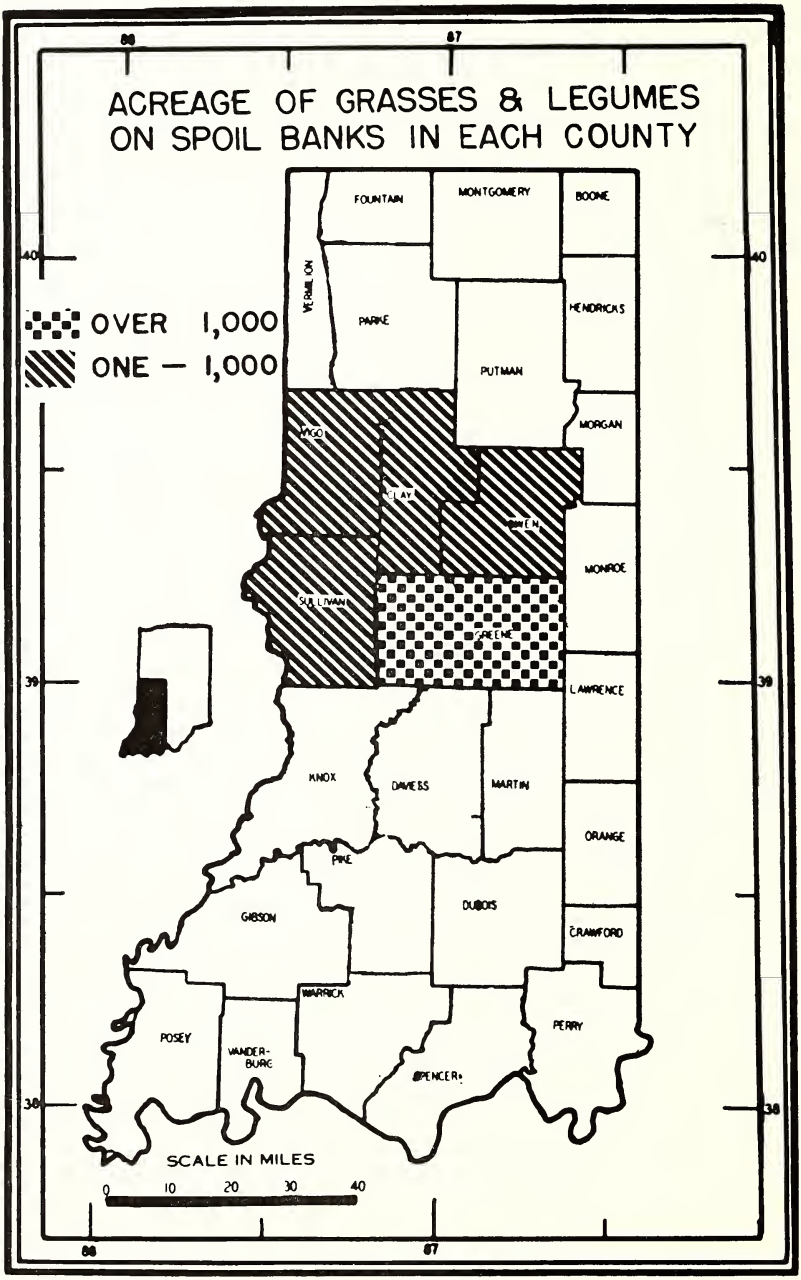
ACREAGE OF GRASSES & LEGUMES
ON SPOIL BANKS IN EACH COUNTY
OVER 1,000
ONE — 1,000
FOUNTAIN
MONTGOMERY
BOONE
VERMILION
PARKE
HENDRICKS
PUTNAM
MORGAN
VIGO
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
KNOX
DAVIESS
MARTIN
ORANGE
PIKE
DUBOIS
GIBSON
CRAWFORD
WARRICK
POSEY
VANDER-
BURG
SPENCER
PERRY
SCALE IN MILES
0 10 20 30 40
86
87
40
39
38

Figure 5

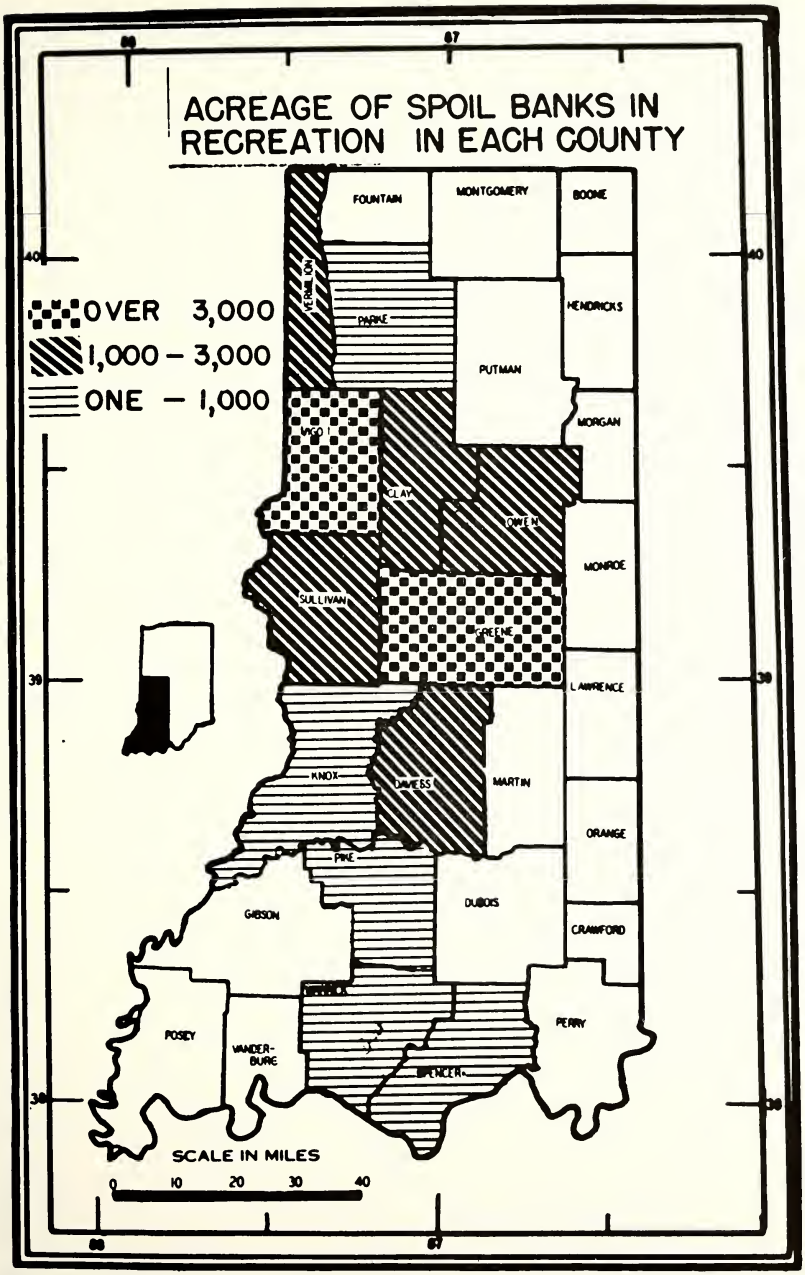
ACREAGE OF SPOIL BANKS IN RECREATION IN EACH COUNTY
OVER 3,000
1,000 – 3,000
ONE – 1,000
FOUNTAIN
MONTGOMERY
BOONE
VERMILION
PARKE
HENDRICKS
PUTNAM
MORGAN
VIGO
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
KNOX
DAVIESS
MARTIN
ORANGE
PIKE
GIBSON
DUBOIS
CRAWFORD
WARRICK
POSEY
VANDER-BURG
SPENCER
PERRY
SCALE IN MILES
0 10 20 30 40

Figure 6

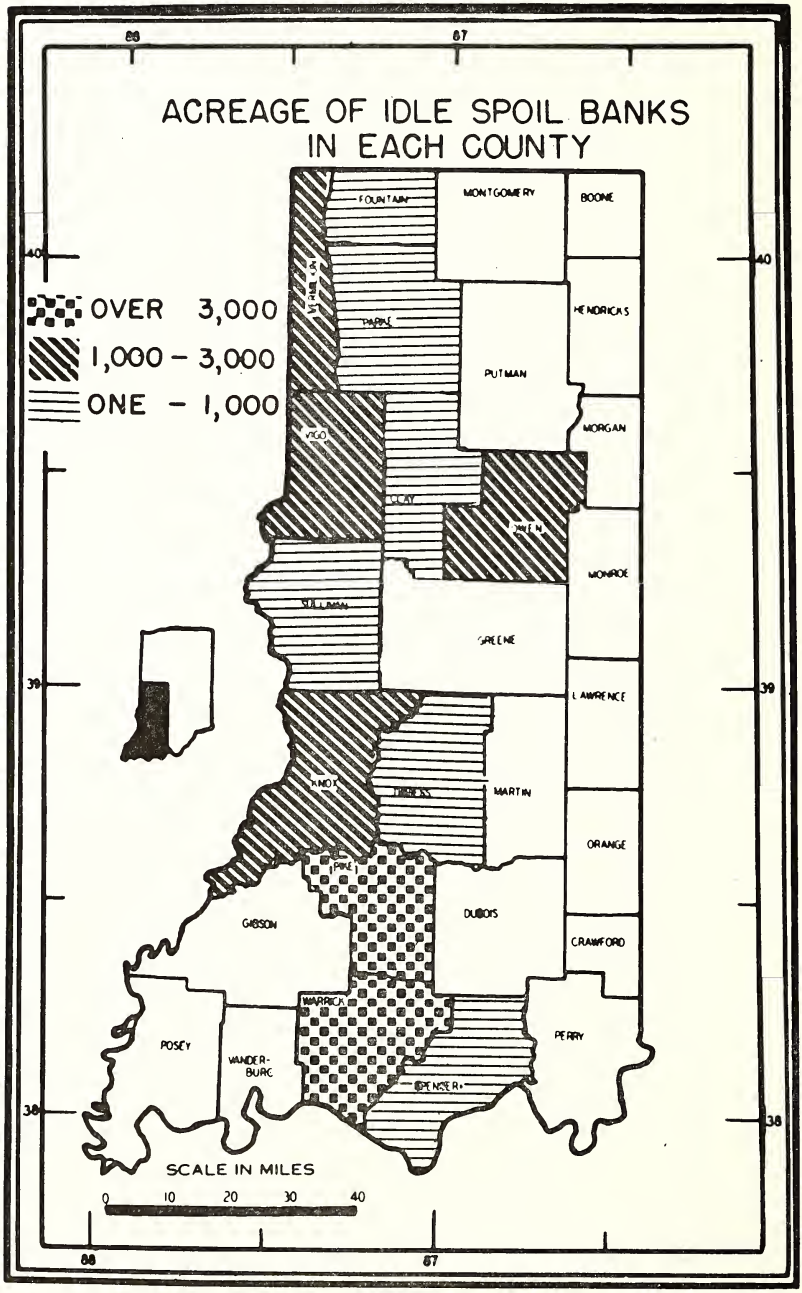
ACREAGE OF IDLE SPOIL BANKS
IN EACH COUNTY
OVER 3,000
1,000 – 3,000
ONE – 1,000
FOUNTAIN
MONTGOMERY
BOONE
PARKE
PUTNAM
HENDRICKS
MORGAN
VIGO
CLAY
OWEN
MONROE
SULLIVAN
GREENE
LAWRENCE
MARTIN
ORANGE
PIKE
GIBSON
DUBOIS
CRAWFORD
WARRICK
POSEY
VANDER-
BURG
SPENCER
PERRY
SCALE IN MILES
0 10 20 30 40
86
87
40
39
38

Figure 7

trap except along the county roads. But reclamation developments in Indiana have demonstrated that the recreational possibilities of strip mined lands is far from being realized.

Twenty-six per cent of Indiana's spoil banks are idle. Of the 24,814 acres still idle, about 60 per cent is located in Pike and Warrick Counties. The idle land occurs for two primary reasons: (1) Spoil banks which are being weathered in preparation for grading and planting. (2) Spoil banks which are 18 years old or older and were mined before reclamation was legally required. With the combined impact of these two factors, idle lands are prevalent in most Indiana counties (Fig. 7).

Only 364 acres of strip mined lands were reported as tax delinquent in 1959. This represents less than one-half of 1% of all spoil banks. Spoil banks are normally held onto in Indiana because the owners are aware of the numerous potential land uses to which they can be put after the coal is removed. In addition, the possibilities of mining the deeper coal seams later cause mining companies to retain the land (7).

In conclusion, there is significance in the extent and wide variety of different land uses of Indiana's spoil banks. The mining of 50,495 acres of cropland has caused numerous impacts to those farming areas. Within Southwestern Indiana, 93,836 acres of land have been converted to spoils. They have certainly created considerable economic instability in those areas primarily affected.

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Pebble Counts in the Glacial Tills of Parke and Putnam Counties, Indiana

C. L. Bieber, DePauw University

Introduction

Unweathered and unoxidized tills of west-central Indiana are difficult to differentiate. The present study is progress reported on a long range statistical approach to the age-recognition problem. Pebbles from the tills have been collected and classified in the hope that statistical differences would appear. Eight areas were selected for sampling, 6 of which are from Putnam County and 2 from eastern Parke County. One Kansan?, 3 Illinoian, and 4 Wisconsin till sites are included in the group.

Sampling Procedure

Sampling location map.

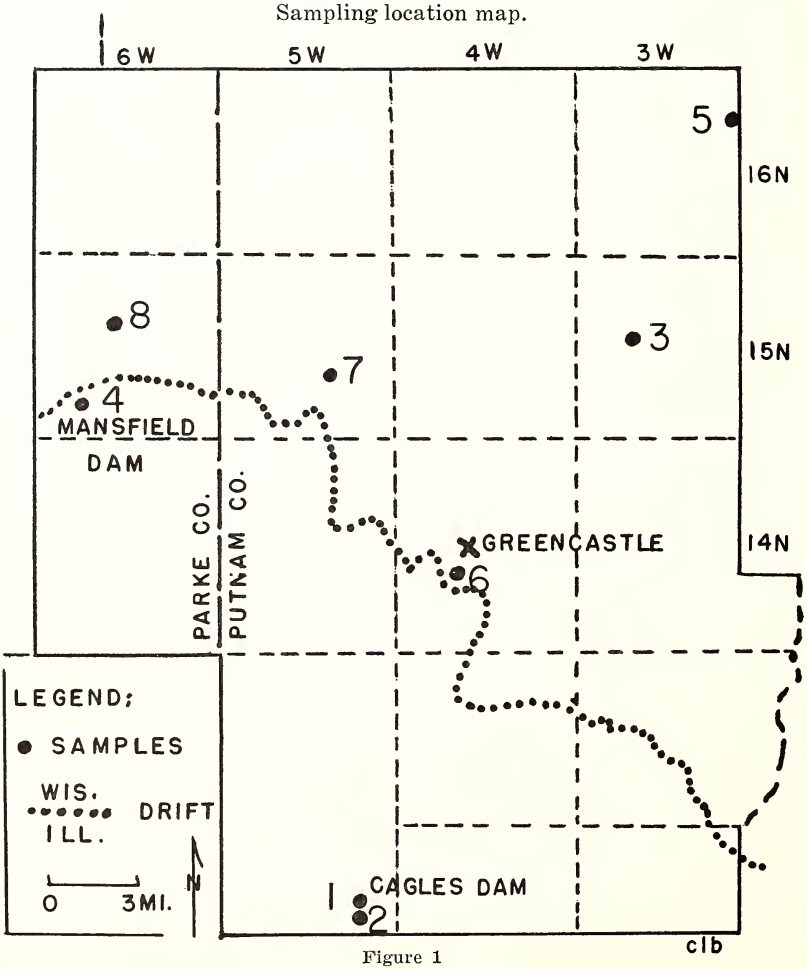

Figure 1

Sampling locations:

1. Kansan? NW¼ sec. 13, T. 12 N., R. 5 W.
2. Illinoian NW¼ sec. 13, T. 12 N., R. 5 W.
3. " SW¼ NW¼ sec. 16, T. 15 N., R. 3 W.
4. " NW¼ sec. 27, T. 15 N., R. 6 W.
5. Wisconsin SE¼ NE¼ sec. 13, T. 16 N., R. 3 W.
6. " NW¼ sec. 29, T. 14 N., R. 4 W.
7. " NE¼ sec. 22, T. 15 N., R. 5 W.
8. " NE¼ SW¼ sec. 10, T. 15 N., R. 6 W.

Sampling sites were selected which exposed at least 10 feet of unoxidized till. If the bank was stable, pebbles were collected from in place. One hundred pebbles were taken as a representative sample. Pebbles approximately one-half to one inch in diameter were chosen. On most sites, a vertical path was taken up the bank, picking all pebbles of the selected size. In two cases of cuts made by man, pebbles were collected after each step from a circle 2 feet in diameter with the collector's foot as the center. A hand screening device was tried at the outcrop, but was found to be too slow.

An attempt to sample only igneous and metamorphic pebbles was made. The samples are thought to be fairly representative, though the human tendency to choose certain colors, shapes, or locations undoubtedly influence the results. It is far better to collect all pebbles, and then choose the igneous and metamorphic ones from the entire sample.

Samples were carried to the laboratory and washed. Each pebble was then cracked and examined with a hand lense. Separation into 14 piles was attempted. The carbonate pile and other questionable pebbles were subjected to a test with HCl acid and a rough separation into limestone and dolomite was then made. After the identification, pebbles were moved to age determination piles. This was done mainly by lithology, color, weathering, and experience of the writer in Indiana stratigraphy.

Interpretation

From northeastern Putnam County westward into Parke County the limestone pebbles in the Illinoian till increase in number, while the dolomite pebbles remain about the same. In the same area for Wisconsin till, both the limestone and dolomite pebbles fall off in number westward. Chert pebbles are common in both tills, and increase proportional to other pebbles in the leached zones. The number of chert pebbles is in part dependent upon the locality of outcrop of the St. Louis limestone, the upper part of which is locally cherty. Up to 10% of the pebbles in the eastern part of the sampled area are siltstone and fine sandstone, reflecting the Borden group. Sandstone pebbles with ironstone are common westward in small percentages where tills are in close association with Pennsylvanian sandstone strata. Devonian black shale fragments are common in the eastern part of Putnam County, and even persist into Parke County where Devonian black shale may become confused with Pennsylvanian shale in the tills.

Igneous pebbles in all tills make up about 25% of all pebbles in the unleached tills. Felsic rock types (light) are less than the mafics (dark)

by about one-third. Pebbles in the Illinoian and Wisconsin tills, which constitute the exposures of till in the northeast part of the area, are remarkably similar in composition and in area of accumulation. Greenstone (basalt-like) pebbles stand out modestly in the Illinoian, as do weathered crystalline mafic pebbles and chert. However, in fresh unaltered till pebble differences in the two tills are difficult to distinguish. Pebble

TABLE I. Average area tills.

	Kansan?	Illinoian	Wisconsin	Average Illinoian-Wisconsin
Limestone	22	15	16	16
Dolomite	11	20	20	20
Sandstone	21	1	0	1
Siltstone	5	7	9	8
Shale	2	3	1	2
Chert	4	22	21	21
Iron-stone	0	1	1	1
Granite (& gneiss)	3	7	3	5
Diorite	3	4	4	4
Gabbro	4	2	3	3
Felsite	0	0	0	0
Andesite	8	4	4	4
Basalt	10	8	8	8
Quartzite	7	5	8	6
Slate-Schist	0	0	1	1

TABLE II. Average Igneous and Metamorphic Pebbles (in %)

	Erie Lobe (1)	Kansan?	Illinoian	Wisconsin	Average Local Till
Felsic, granite	20	30	26	16	24
Medium mafic	18	13	21	18	17
Mafic	34	27	37	41	35
Quartzite, quartz	25	25	9	24	19
Other	3	5	7	1	5

TABLE III. Age of Original Pebble Rock (in %)

	Kansan?	Illinoian	Wisconsin	combined Ill.-Wis
Pennsylvanian Ss.	21	0	0	2
Mississippian Ls.	13	11	10	10
Mississipian chert	1	17	16	16
Older chert (weathered)	3	4	6	5
Borden siltstone	5	7	10	8
Devonian shale	2	4	1	2
Dev.-Silurian Ls.	9	4	6	5
Dev.-Silurian dolomite	11	20	20	20
Precambrian	28	29	30	29
Other	7	4	1	3

counts and origin studies show that the ice for both Illinoian and Wisconsin tills came from the same general locality (northeast), though Borden pebbles indicate more of a north-south trend during at least a part of the Wisconsin advance. Some of the similarity in pebble content results from the Wisconsin ice reworking the older Illinoian surface. As might be expected, Devonian black shales are more common in the older tills. An average by age of pebbles from Illinoian and Wisconsin tills show 2% Pennsylvanian, 34% Mississippian, 32% Devonian and Silurian, 29% Precambrian, and 3% unaccounted.

Conclusions

1. Pebbles in the tills of Northern Putnam and East Parke Counties were probably derived from nearly the same sources.
2. In southern Putnam County the till samples collected are so close to exposures of Pennsylvanian sandstone and shale, that percentages are locally affected.
3. Over 30% of the till pebbles were not transported over 20 miles; 25 to 30% traveled over 400 miles.
4. Some 30% of the pebbles in the tills are Mississippian limestones and siltstones; nearly 30% are igneous and metamorphic, the balance are middle and lower Paleozoic age.

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Technology and Economic Geography[1]

Otis P. Starkey, Indiana University

Geography textbooks, papers, and films are commonly overloaded with technological details which have minor relevance to the basic problems of economic geography. From the point of view of general education, it may be desirable to include details on sugar refining, blast furnaces, and flour mills. But such inclusions often are at the expense of more relevant geographic data. Where shall we draw the line?

It is recommended that the test be: *does the technological data significantly explain the way the land is being used?*

This paper will utilize data from the Lesser Antilles to exemplify the proper use of technology in economic geography. Here the value of this kind of data is especially clear because changing technologies have altered the relative value of various islands for producing particular export crops.

A preliminary word on the Lesser Antilles will set the stage. Each island is small: generally smaller than a Hoosier county; Montserrat is slightly smaller than a congressional township. As there is considerable variety of relief, soil, and climate on each island, the size of the land unit adaptable to a particular industry may be a fraction of that island's area. All of these islands were sugar islands until 70 years ago, when the competition of beet sugar forced them to seek other crops. Especially during the first decade of the twentieth century, all tried alternate crops; for example, Grenada shifted to nutmeg and cocoa, St. Vincent to arrowroot and Sea Island cotton, and Montserrat to limes. Some islands, such as Barbados, Antigua, and St. Kitts, were unsuccessful in their search for alternate crops. With the aid of cultural improvements, new cane varieties, large and more efficient factories, and tariff and quota help from mother countries, these islands put their sugar industries on a competitive basis.

The Question of Scale. Some of the changes in the competitive situation involve changes in the idea of what constitutes a large scale operation. Modern technology seems to favor increasingly large scale; most of the islands cannot turn out enough to support a technically efficient unit. For example, sugar factories should produce at least 10 to 20 thousand tons.

St. Kitts is fortunate in having one large sugar factory with a capacity of 65,000 tons. This is possible because the sugar estates are located on the gentle slopes of volcanoes. Although these units are separated from each other by steep ravines, a narrow-gauge railway bridges these ravines and conveys the canes expeditiously to the factory and thence the sugar and molasses to the wharves. Thus St. Kitts has survived in the sugar business because its geographic setting permits production on an efficient scale.

In contrast is St. Lucia, until recently one of the sugar islands. Its alluvial sugar soils are divided among four valleys separated from each other by miles of rugged land. Its total production never exceeded 10,000

[1] The examples used in this paper were collected during work under a contract between Indiana University and the Office of Naval Research.

tons divided among four semi-modern factories. During World War II, the southernmost sugar area was converted into a U. S. airbase. In 1958, the area supplying Dennery factory was shifted to bananas. Recently the banana interests bought the other two sugar valleys and expect to continue sugar manufacture in one of the two remaining factories, primarily to supply local markets.

The problem of scale is also exemplified by the poor shipping service which plagues the islands. Ocean-going freighters generally do not find it worth stopping for a small cargo: their minimum requirement may be from 100 to 300 tons. Consequently, freighters from Canada and the United Kingdom only stop on the south-bound trip (usually once a month) and stop on the north-bound trip only when enough produce has accumulated. Small inter-island boats handle some of the trade by transshipment at Barbados and Trinidad, but this adds to the price of goods on less populous islands.

Better loading equipment and larger cargo result in lower shipping costs for the more productive islands. Barbados is installing bulk-loading facilities which will load sugar at the rate of 500 tons per hour. With such equipment, the entire annual cotton output of Montserrat could be loaded in three and a half hours, and the sugar crop of Antigua could be loaded in two and a half days.

Accessibility to Market. Sugar, Sea Island cotton, arrowroot, cocoa, and spices can be shipped to the market when convenient, but the marketing of perishable products such as bananas and tomatoes requires rapid, refrigerated shipping. Such ships are not profitable unless the business is on a large-scale basis with a regular cargo.

Until recently, the British Lesser Antilles had good refrigerated service to Canada by boats operated and subsidized by the Canadian government. Tomatoes, carrots, and onions were shipped to Bermuda and Canada until steamship service was discontinued because of labor difficulties. Then the vegetable growers sought markets to the south in Trinidad and British Guiana; available shipping to these points had inadequate refrigerated space for the cargoes offered, and often the produce spoiled and was dumped into the sea.

In contrast is the recent development of the banana industry in the Windward Islands. Here the credit goes to one company, Geest Industries, which has agreed to buy all bananas offered that meet their specifications. As a result, the "Green Gold" boom has spread into Grenada, St. Vincent, St. Lucia, Dominica, and, very recently, into Montserrat.

Take St. Lucia. On Wednesday afternoon the stores close; all busses have their seats and roofs removed and become banana trucks. At collecting points throughout the island, Geest representatives are buying banana stems for 5¢ a pound, provided they are ⅞ ripe, unbruised and unscratched, and weigh over 18 pounds a stem. The approved bunches are weighed, put into plastic bags, and loaded on busses. Thursday at dawn the white banana boat arrives, women head the stems up the gangplank, and by sunset the boat is off to Dominica.

How different is the banana industry at Montserrat, born August 20, 1959! Here the bananas are the Montserratan hope because their

former crop, Sea Island cotton, is no longer profitable. The Montserrat banana crop is too small to justify a visit from the banana boat. So Montserrat bananas are picked Thursday, ¾ (not ⅞) ripe, and are shipped via a small Montserrat-owned, non-refrigerated steamer which will connect with the banana boat at Dominica Friday morning. Montserratans get 4¢ a pound for their bananas, not 5¢, and there are many more rejected stems than at St. Lucia.

Concluding Remarks. Other illustrations could be given to show the geographic value of technological data. Mention could have been made of the influence of agricultural machinery, new strains of plants and animals, and new techniques of fertilization—all of which have a significant bearing on land use. There is no need to include the *details* of cane cutting, sugar manufacturing, or cotton ginning, which have minor influence. Geographers have enough relevant material to fill all available space in their writing; hence all technological material should be tested and pruned before it is submitted for publication.

Stratigraphic Relations of the Merom Sandstone Near Merom, Indiana[1]

Charles E. Wier, Indiana Geological Survey

The purpose of this paper is to present and discuss data bearing on the stratigraphic position of the Merom Sandstone in its type region. The exact stratigraphic position of this sandstone of late Pennsylvanian age has been in doubt for some time. Most of the confusion has been brought about by the fact that its relationship to well-known strata below it has never been clearly determined at its type locality. Because of its prominent exposure in the Wabash River bluff at Merom, Sullivan County, Ind. (fig. 1), and its bluff-forming characteristics elsewhere, it received a name long before most rock units above and below it. It was first described by John Collett in 1871 (2). He stated that "the stone work of the college edifice (at Merom) was quarried from massive ledges of the 'Merom sandstone' north of town . . ." He also referred to this sandstone as the "Anvil Rock," but the Anvil Rock Sandstone in Kentucky is much older than the Merom of Indiana. Later workers continued to use the term Merom for the Indiana sandstone.

The bluff facing the Wabash River at Merom rises from an altitude of 430 feet on the bank of the river to 585 feet on top of the hill at the Merom Institute. At most places along the 2-mile length of the bluff the difference in relief is more than 100 feet. Although many excellent outcrops do occur along this bluff, more than 30 feet of exposed rock is uncommon. Commonly the lower half of the bluff is covered by talus material, and Wisconsin outwash sands and gravels fill the valley.

The upland area is covered with a mantle of loess of Wisconsin age and a small amount of windblown sand. Beneath the loess and overlying the bedrock is a blanket of till of Illinoian age. Although the Merom Sandstone is the topmost bedrock unit, it is not exposed on the upland because of the till and loess cover.

The sandstone ranges from 10 to 35 feet in thickness at most exposures and is not known to exceed a thickness of 40 feet at any locality. The Merom Sandstone consists of two distinct lithologies: (1) an upper crossbedded medium- to coarse-grained sandstone and (2) a lower conglomerate. The upper unit weathers into tan to brown massive nearly vertical faces that have a fretted appearance and uneven parallel streaks. Where fresh and unweathered the sandstone is light gray. At some localities, especially in the upper few feet, the sandstone has thin regular bedding, but, in general, crossbedding is the rule. In a petrographic study of 16 samples from 3 localities on the bluff at Merom, Larson (4) determined that the nonconglomeratic part of the Merom Sandstone consists of 85 to 90 percent quartz, 5 to 10 percent feldspar (mostly microcline and orthoclase), less than 1 percent mica (mostly muscovite), and less than 5 percent heavy minerals (mostly limonite and hematite). The sand

[1] Published with permission of the Acting State Geologist, Indiana Department of Conservation, Geological Survey.

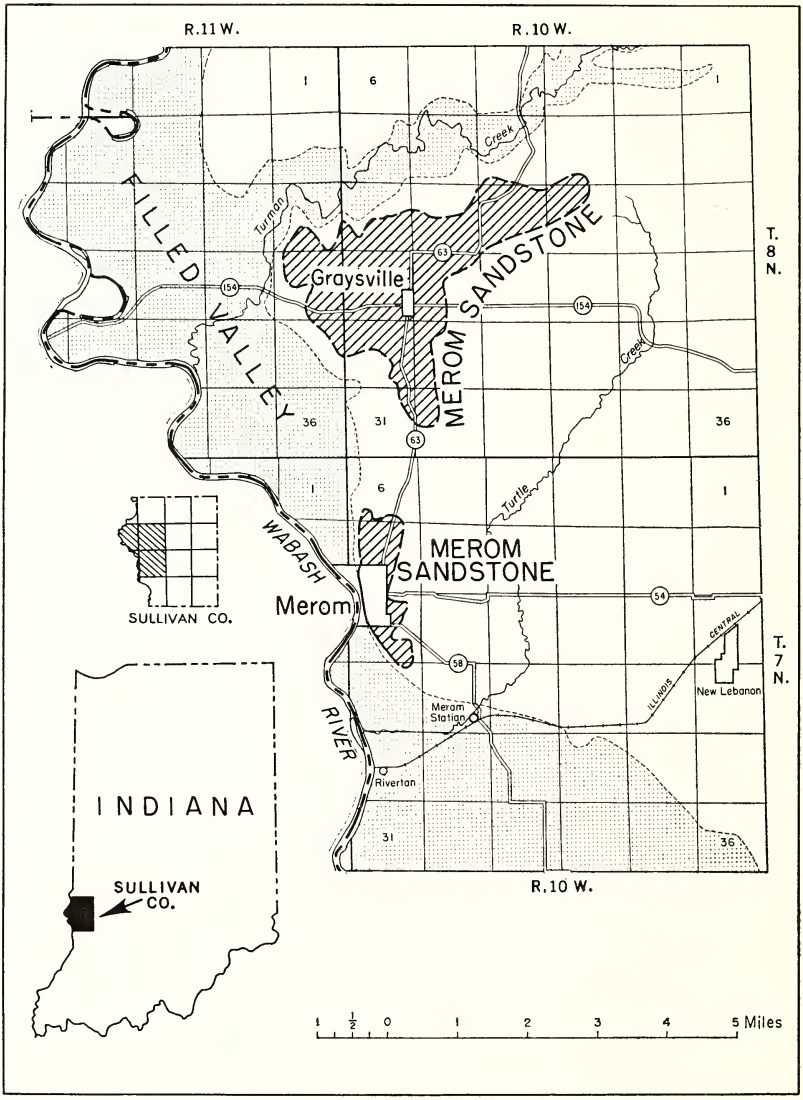

Figure 1. Map of west-central Sullivan County showing area underlain by the Merom Sandstone. Modified from Wier (5).

grains are well sorted (sorting coefficient 1.44), subrounded (roundness of 0.3), and medium-grained (mean size of 0.31 mm).

The basal conglomerate is gray to brown and is composed of a mixture of rounded to subrounded pebbles of limestone, chert, sandstone, coal, and clay. The pebbles are cemented by calcium carbonate. Fossils are common. They consist chiefly of brachiopods and crinoid columnals of various sizes.

This conglomerate ranges from 2 to 10 feet in thickness and at nearly all exposures along the bluff rests directly on the Livingston Limestone (fig. 2).

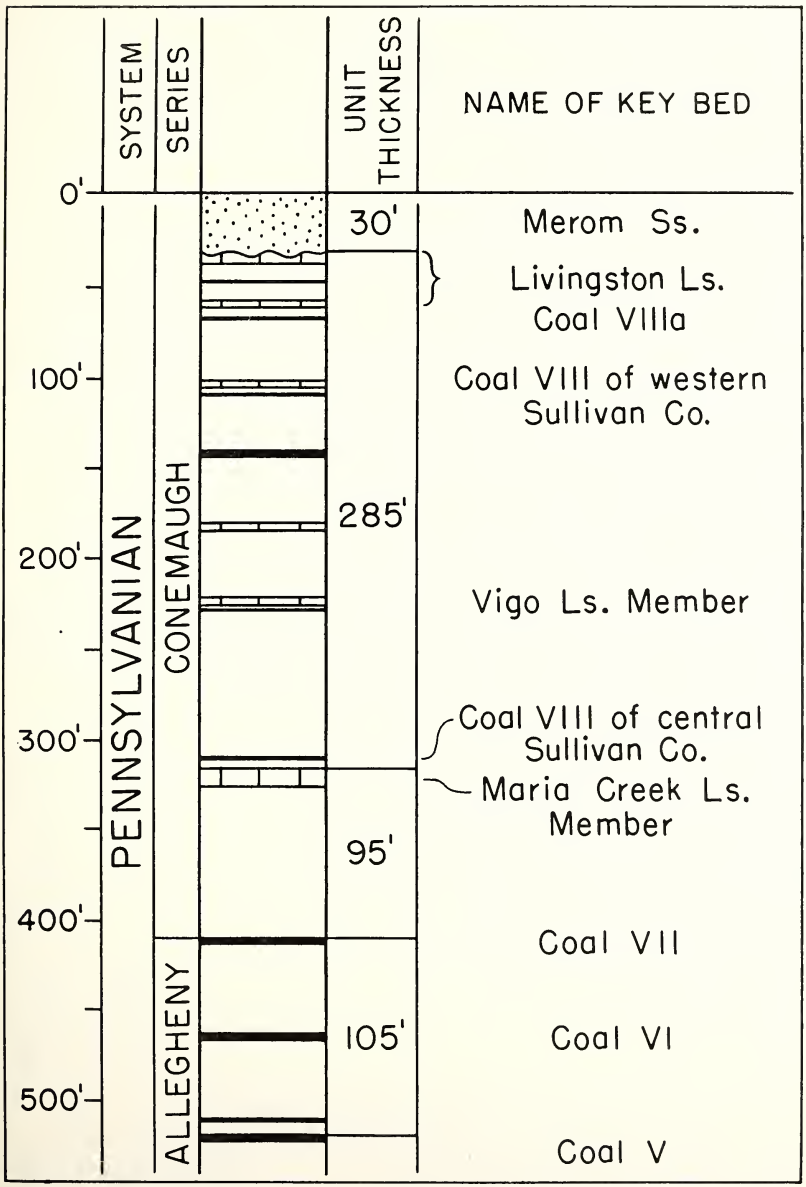

Figure 2. Skeletal columnar section showing relationship of Merom Sandstone to underlying coals and limestones.

The following stratigraphic section is representative of exposures along the bluff and is located a quarter of a mile south of the Merom Ferry in the NW¼NW¼ sec. 18, T. 7 N., R. 10 W.

	Thickness (feet)
MEROM SANDSTONE	
Sandstone: gray to tan, crossbedded, medium- to coarse-grained, subangular	17.0
Sandstone: tan, medium- to coarse-grained subangular; contains clay galls and ironstone nodules in upper 3 feet	8.5
Sandstone: light-gray, fine- to medium-grained; contains calcareous cement	2.5
Conglomerate: gray to brown; contains fragments of limestone, chert, coal, and sandstone in a calcareous cement	5.2
Total exposed thickness of Merom Sandstone..	33.2
LIVINGSTON LIMESTONE	
Limestone: dark-gray; contains abundant crinoid fragments and the large brachiopods *Linoproductus prattenianus* and *Echinoconchus semipunctatus*	4.0
Total thickness of measured section	37.2

The following composite section shows the rocks beneath the Merom Sandstone. It was compiled from 15 outcrops along the bluff and from a record of a drilling located between the bluff and the river in the NW¼NW¼ sec. 18, T. 7 N., R. 10 W., and it was modified and condensed from Wier (6).

	Lithologic Unit	Unit thickness (feet)	Depth (feet)
1.	Sandstone (*Merom Sandstone*)	32	32
2.	Limestone (upper *Livingston Limestone*)	4	36
3.	Shale: medium-gray	2	38
4.	Coal: bright, banded	2	40
5.	Shale: light-gray to black	18	58
6.	Limestone: blue-gray, nodular, argillaceous; contains abundant crinoid columnals (lower *Livingston Limestone*)	2	60
7.	Clay and shale	10	70
8.	Coal	1	71
9.	Underclay	4	75
10.	Shale, siltstone, and sandstone: locally contains a few inches of limestone or a gastropod-rich shale at the base. (Position of massive sandstone in Chimney Hills, sec. 31, T. 2 N., R. 10 W.)	43	118
11.	Coal	1	119
12.	Underclay	2	121

13.	Shale: light- to dark-gray; contains siderite bands near the base that locally contain brachiopods. (Position of massive sandstone in Wolf Hill, sec. 11, T. 4 N., R. 10 W., and at Old Fort Knox, surveys 50 and 51, T. 3 N., R. 10 W.)	38	159
14.	Coal	4	163
15.	Underclay	5	168
16.	Sandstone and shale	30	198
17.	Limestone: light-gray; contains brachiopods and crinoid stems	1	199
18.	Underclay	1	200
19.	Sandstone and shale. (Position of massive sandstone in eastern Clark County, Ill.)	35	235
20.	Limestone: black, argillaceous; contains brachiopods *(Vigo Limestone Member)*	1	236
21.	Shale: black, fissile	2	238
22.	Coal: bright, banded	1	239
23.	Clay and shale: contains siderite and limestone streak at the base	11	250
24.	Shale and sandstone: locally contains a coal near the base (*Coal VIIIa* of Ashley). (Position of massive sandstone northwest of Bicknell, T. 4 N., Rs. 8 and 9 W.)	67	317
25.	Limestone: gray to light-brown, finely crystalline; contains brachiopods and crinoid columnals *(Maria Creek Limestone Member)*	4	321
26.	Shale: gray to black; locally green and red	7	328
27.	Shale, siltstone, and sandstone	21	349
28.	Coal: bright, banded	1	350
29.	Shale and sandstone: *(Busseron Sandstone Member)* (Position of massive sandstone in central Sullivan County.)	62	412
30.	Coal: bright, banded *(Coal VII)*	3	415
31.	Underclay	5	420
32.	Limestone: gray, sublithographic *(Universal Limestone Member)*	1	421
33.	Sandstone, siltstone, and shale	35	456
34.	Coal: bright, banded *(Coal VI)*	4	460
35.	Clay	1	461
36.	Limestone: dark-gray, argillaceous; contains brachiopods and crinoid columnals	2	463
37.	Shale: dark-gray to black	6	469
38.	Coal: shaly	1	470
39.	Clay	3	473
40.	Shale and siltstone	28	501
41.	Coal: bright, banded *(Coal Vb)*	3	504
42.	Shale and siltstone	10	514
43.	Limestone: dark-gray, argillaceous; contains brachiopods *(Alum Cave Limestone Member)*	1	515

44.	Shale: black, fissile	1	516
45.	Coal: bright, banded *(Coal V)*	3	519

The only outcrops of Merom Sandstone in Sullivan County are found within the Merom and Graysville outliers. Although the known bedrock altitudes indicate that the Merom Sandstone is absent to the northwest of the Graysville outlier, a few acres of this sandstone may be present on the north side of Turman Creek beneath thick glacial drift. Numerous exposures may be found on the upland to the northwest in Clark County, Illinois.

Because sandstones, both above and below the Merom, exhibit similar massive exposures, they have been mistaken for it. Good exposures of these sandstones and of adjacent rocks are rare along the Wabash River in southwestern Indiana and in Illinois because of the low relief, the wide and deeply filled valleys, and the mantle of till, loess, and windblown sand that covers the upland adjacent to the valley. In some places many miles of covered area intervene between exposures. Because many outcrops consist of sandstone, without the more diagnostic coals and limestones, it is difficult to place these sandstones in their proper stratigraphic position. Perhaps the false presumption that the Merom Sandstone is the only well-developed sandstone near the top of the Indiana stratigraphic column has resulted in the higher sandstones being referred to the Merom horizon. Another erroneous assumption is that the Merom Sandstone is as much as 150 feet thick instead of actually 30 feet, simply because the Merom Bluff is more than 150 feet high.

G. H. Ashley (1), in his excellent summary of all available coal information, caused some confusion by identifying both the coal that overlies the Maria Creek Limestone Member in central Sullivan County (fig. 2) and the coal that occurs 75 feet below the Merom Sandstone at Merom as Coal VIII. Ashley assumed that the Merom Sandstone averaged 194 feet above Coal VII instead of the actual 380 feet. Thus Ashley used the name Merom for all massive sandstones above the Maria Creek Limestone Member in areas to the south, especially for those sandstones in Knox County. Numerous sandstone exposures in Wolf Hill, 8 miles north of Vincennes (sec. 11, T. 4 N., R. 10 W.), and in the area where U. S. Highway 41 crosses Maria Creek (sec. 24, T. 4 N., R. 10 W.) were called the Merom by Collett in 1874 (3) and by Ashley in 1899 (1), but the sandstone is actually older than the Merom. The sandstone that crops out in the bank of the Wabash River at old Ft. Knox (survey 51, T. 3 N., R. 10 W.) is also older than the Merom. Thus Merom Sandstone is not present in Indiana in the 25-mile area south of Merom. The Merom Sandstone may be present, but hidden by till and loess, near the top of Ft. Knox Hill. This would be the first occurrence of the Merom Sandstone in Indiana south of the type locality. Across the river from Ft. Knox, in Illinois, the Merom is present near the top of Robeson Hill.

If one has to depend solely on isolated outcrops of sandstone in order to correlate them, the correlations are uncertain. Enough lithologic variation occurs to allow two sandstones of different age to look alike and two sandstones of the same age to look different. Although the Merom Sandstone seems to be more persistent than most of the older sandstones,

in some localities it grades laterally into shale within a few miles. The best method of correlating the sandstones is to use key beds, such as coals and limestones, that are stratigraphically adjacent. Because younger rocks are not found north of Vincennes, we must utilize the older key beds that lie below the Merom Sandstone. The Merom Sandstone commonly rests unconformably on or within a few feet of one of the benches of the Livingston Limestone (fig. 2). Two large and distinctive brachiopods, *Linoproductus prattenianus* and *Echinoconchus semipunctatus*, are abundant in the Livingston; and, because they are not abundant in any other limestone in Indiana, they serve to identify the Livingston.

Unfortunately, outcrops of the Livingston Limestone cannot be found beneath many of the sandstone exposures. Thus the exact stratigraphic position of the sandstone can be determined only by using drilling information. The Maria Creek Limestone Member, which is 285 feet below the base of the Merom Sandstone (fig. 2), is the first good key bed below the Merom that can be picked readily in drillers' and electric logs. Where this limestone is poorly developed or its identification is uncertain, the intervals between the tops of Coals VII and V, which are respectively 380 feet and 485 feet below the Merom, can be used. These intervals apply only to Sullivan County and northern Knox County; the intervals increase greatly south of Vincennes, but Coals VII and V can still be used as marker beds.

Because of the vertical repetition of similar lithologies and the lateral variation of each lithology, correlation of rock units in Pennsylvanian rocks is difficult; but by paying careful attention to altitudes and intervals between units, the geologist can do a satisfactory job with the most difficult correlation problems.

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The Kalamazoo Valley Paper Industry

ELMER B. HESS, Valparaiso University

An old slogan frequently heard in the Kalamazoo Valley is "everything including some newsprint." That expresses in a few words the variety of products produced by the leading industry in the Kalamazoo River Valley. The truth of the slogan is revealed in the variety of papers manufactured: rag bonds, both ledger and writing; sulphite bond—coated and uncoated book, sulphite bristol, postage stamp paper, and greeting card paper; tissue and wrapping paper, box board, ice cream carton board, and butter carton board; playing card stock, and some specialties.

Rank of Michigan in the Paper Industry of the United States

The manufacturing of paper and allied products in the United States is a huge industry. The value added by manufacturing in 1947 totaled $2,874,958. Employment was provided for 449,833 employees.

Paper and allied products ranked tenth among the industries of the United States in 1947; it was outranked by such industries as food, textiles, machinery, and iron and steel.[1]

In 1947 Michigan ranked fourth in terms of value added by manufacturing and sixth in employment. In that year 26,022 persons were employed in paper and allied products mills in Michigan against 65,026 persons for New York, 28,144 persons for Wisconsin, and 31,674 persons for Ohio. In 1947 value added by manufacturing in the paper and allied products industry in Michigan amounted to 174 million dollars while that of New York was 232 million dollars and that of Wisconsin was 188 million dollars.

The paper-producing states can be divided into two major categories on the basis of the amount of paper and wood pulp produced and on the market or raw-material orientation of these products. The market oriented states are all within the North American Manufacturing Belt on a line from Massachusetts to Minnesota. The raw-material oriented states are separated into two groups; those primarily using northern coniferous forests (including the Pacific Northwest) and those using southern coniferous forests for raw materials.

The rank of Michigan in the North American Manufacturing Belt reflects certain advantages of the State: The central position within the American Manufacturing Belt, the presence of abundant labor, the presence of excellent labor relations, and the ease of obtaining raw materials and of shipping finished products.

Rank of the Kalamazoo Valley among Paper Producing Areas in Michigan

Of the 160 paper and allied products mills in Michigan reported in the 1947 *Census of Manufacturers*, thirty-six, or nearly one-fourth, were located within the Kalamazoo and Allegan County area—the two counties

[1] Calculated on the basis of value added by manufacturing.

containing the paper mills of the Kalamazoo Valley. Out of a total of 26,022 persons employed in the mills (within the state in that year), 7,945 were in Kalamazoo County, by far the leading county in the state. This is 31 per cent of the state total. More were employed in adjoining Allegan County for which census figures are lacking. Of a total of 174 million dollars added by manufacturing in the paper industry of Michigan, 49 million dollars was added by the mills of Kalamazoo County.

The Paper Industry in the Kalamazoo Valley

The paper industry of the Kalamazoo Valley is the leading employer in the Valley. It is also the leading industry in value added by manufacturing. In 1947 Kalamazoo County produced manufactured goods valued at 150 million dollars. Of this amount 48 million, or 32 per cent, was in paper and allied products. Besides paper, other important industries include chemicals, metal fabrication, and primary metal production. These other three industries together account for less than paper alone.

During 1947 there were 20,867 employees in Kalamazoo County. Of this total 7,945, or 38 per cent, were in the paper industry. The next largest group in 1947, which consists of 13 per cent of the total industrial employment, was in metal fabrication; this industry accounted for 2,631 employees. The third largest industry, the chemical and allied products industry, accounted for 2,099 employees, or 10 per cent of the total number of employees in the county.

The paper mills of the Kalamazoo Valley are situated in or near four cities—Kalamazoo, Vicksburg, Otsego, and Plainwell (Fig. 1). Vicksburg

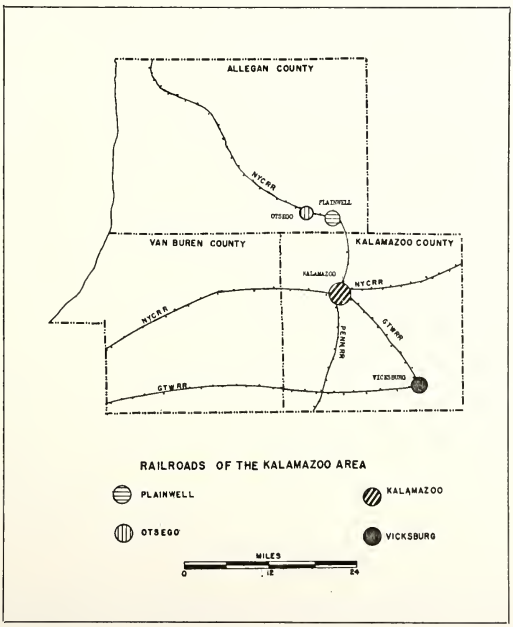

Figure 1

contains the Lee Paper Company; Kalamazoo contains the Allied Paper Company, Kalamazoo Paper Company, Sutherland Paper Company, St. Regis Paper Company, Kalamazoo Vegetable Parchment Company, Rex Paper Company, and other small companies; Otsego contains the Mac-SimBar Paper Company, the Otsego Falls Paper Company, and the Bardeen Division of the Allied Paper Company; Plainwell contains one mill—the Michigan Paper Company.

History of Paper Production

The paper industry of the Kalamazoo Valley has gone through three stages of development: pioneer stage, expansion stage, and consolidation stage.

The pioneer stage, 1866-1872, is characterized by the founding of the first paper mill in Kalamazoo and by the change from water to steam power.

Paper making in the Kalamazoo Valley began in 1866 with the arrival in Kalamazoo of Benjamin F. Lyon. In order to provide water power for a paper mill, Lyon, a paper maker from Massachusetts, began construction on September 8, 1866, of a small dam across Portage Creek, south of Kalamazoo. A small frame building was constructed and the first run of paper was made in 1868.

After the destruction of the original mill in 1872 by fire, a new brick mill was constructed in which steam replaced water as the source of power. Steam had the advantage of being constant the year around; whereas with water power shutdowns were frequent during times of low water.

During the stage of expansion of the Kalamazoo Valley paper mills, 1872-1917, many of the original men of the Kalamazoo Paper Company (the original mill) left that company to form mills of their own. This was the result of the increased demand for paper and paper products. This period is also characterized by the advent of electricity for power. New mills were located not only in the City of Kalamazoo, but throughout the Kalamazoo Valley.

Benjamin F. Lyon left the Kalamazoo Paper Company and organized another paper company twelve miles north of Kalamazoo at Plainwell, Michigan (Fig. 1). This occurred in 1872. The mill was a small frame structure and used power from a mill race which was connected with the Kalamazoo River.

Plainwell's second paper mill was erected in 1887 on land immediately adjoining the Lyon Paper Company. This younger concern absorbed the Lyon mill and became known as the Michigan Paper Company.

George E. Bardeen resigned his position as secretary of the Kalamazoo Paper Company and decided to organize a company of his own. It was but a prank of nature that the site he selected was in Otsego, Michigan (Fig. 1). The spring of 1887 brought an unprecedented flood of water down the Kalamazoo Valley and the site offered by Otsego was the only one that was dry. Work began immediately and the mill was completed by the fall of that year. On December 26, 1887, the first run of paper was made in Otsego. The Bardeen mill was probably among the best equipped in the Middle West at that time. The building was of fireproof construction and was further protected by an automatic sprinkler system.

In 1895 three men associated with George E. Bardeen at Otsego—Noah Bryant, Frank H. Milham, and John F. King—left the Bardeen Company to form the Bryant Paper Company of Kalamazoo. This plant was later absorbed by the Allied Paper Company of Kalamazoo (Fig. 2, No. 3).

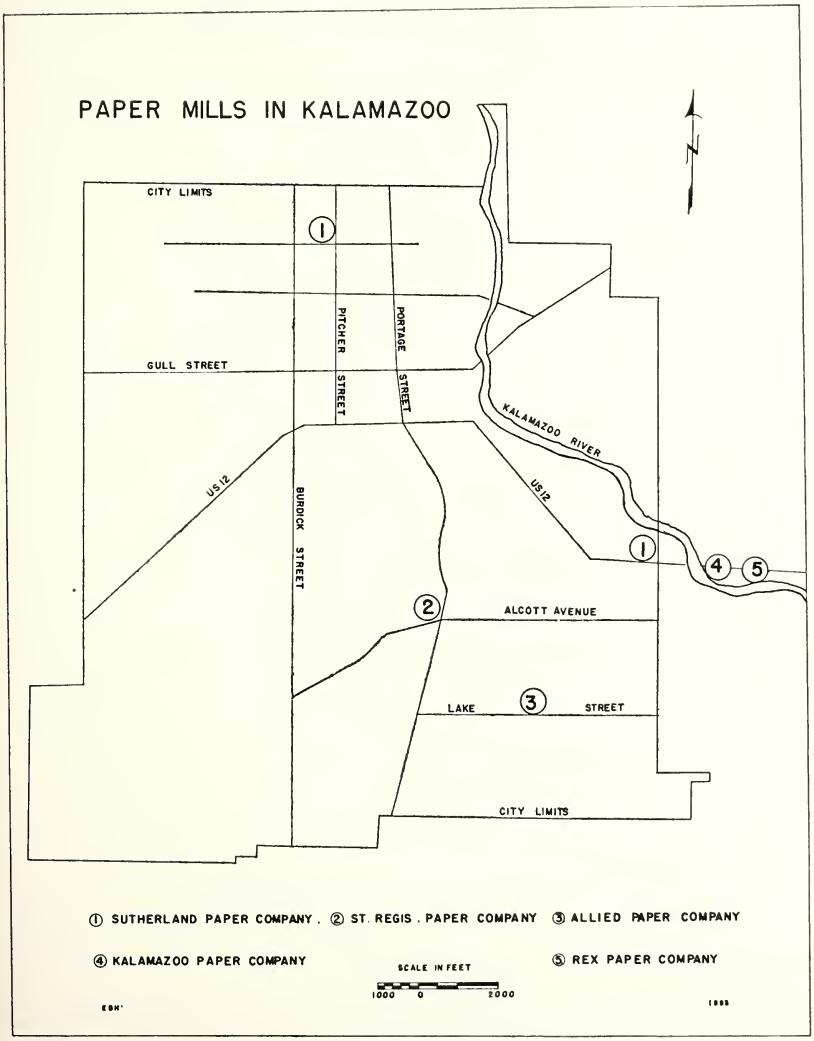

Figure 2

In the late 1890's the Kalamazoo paper industry was increased by the founding of the Wolverine Paper Company. Although this company turned out to be a financial tragedy, the failure made little difference to

the paper industry of the Valley because the Kalamazoo Paper Company bought the defunct Wolverine Company and continued its operation. The Kalamazoo Paper Company moved from its old locations, south of the city, and settled in the Wolverine mill which was on the east side of Kalamazoo (Fig. 2, No. 4).

From 1900 to 1917 there was a tremendous growth in the paper industry of the Kalamazoo Valley. The St. Regis Paper Company was formed in the early 1900's. This was a part of a large paper company having its main offices in New York. In 1901 John King severed his connections with the Bryant Paper Company and formed the King Paper Company. In 1915 John King, along with his son, Merrill King, left the King Paper Company and founded the Rex Paper Company (Fig. 2, No. 5).

In response to a demand for high-grade rag paper, the Lee Paper Company was organized at Vicksburg, Michigan, in 1903 (Fig. 1). The erection of the buildings was begun in the Spring of 1904 and paper production was in operation by January, 1905. The Lee Paper Company produces high-grade bond paper and photographic base paper.

The founding of the Kalamazoo Vegetable Parchment Company was of major importance to the paper industry of the Kalamazoo Valley. This company was organized by Jacob Kindelberger, a German immigrant. Upon coming to Kalamazoo from West Carrolton, Ohio, Kindelberger succeeded in interesting a group of local businessmen in establishing a company for the manufacturing of vegetable parchment. The old plant of the Kalamazoo Beet Sugar Company was purchased and shortly the making of parchment began. The mill was located in open country to the north of Kalamazoo, an area now incorporated in the city of Parchment, Michigan.

The story of the Kalamazoo Vegetable Parchment Company has been one of expansion. The rapid growth of the parchment business led to the erection of a paper mill in 1918. The paper produced was used as raw material for the parchment machines. The mill had two paper machines capable of producing seventy-five tons of paper per day. In 1933 a three-story building was erected for the storage of wood pulp. From an initial capitalization of $50,000.00 the Kalamazoo Vegetable Parchment Company has developed into an industry having assets well over $8,000,000.00.

The founding in 1917 of the Sutherland Paper Company marked the termination of the expansion period of the paper industry in the Kalamazoo Valley. The company was founded by L. W. Sutherland and F. W. Sutherland, both former employees of the Kalamazoo Paper Company. The Sutherland Company was launched in a machine shop on the present site of Plant No. 1 (Fig. 2, No. 1). The organization manufactured butter cartons and was first known as the Kalamazoo Sanitary Carton Company.

The Sutherland Paper Company has specialized in food cartons and asundry products. In 1935 the company began manufacturing food cans for the selling of fresh food and ice cream and at present are one of the three leading manufacturing concerns of paper cans in the United States.

Besides the production of food containers, Sutherland has expanded into the manufacturing of pie plates, paper forks, spoons, and vegetable boxes. The Sutherland Company has a capacity of more than one million paper plates per day.

The third stage of development in the paper industry in the Kalamazoo Valley was one of consolidation. Competition has become strong and successful operation depended upon large production, clever advertising, and new markets.

During this period many of the existing paper companies were consolidated forming fewer but larger concerns. Among these were the Kalamazoo Paper Company, Riverview Coated Paper Company, Monarch Paper Company, King Paper Company, Bryant Paper Company, and others.

The Kalamazoo Paper Company, the first company in the Valley, was particularly active in consolidation. The company assumed control of the Wolverine Paper Company and moved its plant and offices to the Wolverine plant. The original Kalamazoo Paper Company plant was purchased by the Monarch Paper Company. In 1918 the Kalamazoo Paper Company amalgamated with the Riverview Coated Paper Company and after this merger the Kalamazoo Paper Company became one of the largest suppliers of coated paper in the United States.

The Allied Paper Company of Kalamazoo was organized in 1922 by the merger of the King Paper Company, Monarch Company, Bryant Company and the Bardeen Paper Company of Otsego. This company, the Allied Paper Company, is now the largest producer of paper in the Kalamazoo Valley.

Locational Factors

Many factors have influenced the location of the paper industry in the Kalamazoo River Valley. The factors include the location of raw materials, location of markets, and transportation facilities, and the influence of labor.

The raw materials used in the paper industry of the Kalamazoo Valley are diverse in character and origin. The industry utilizes vegetable fibers, water, chemicals, and minerals.

Vegetable fibers form the basic material used in the manufacturing of paper. These fibers can be subdivided into four major categories—wood pulp, paper stock, rags, and cotton linter.

The differences in the internal structure of various papers are determined by the type of fiber used and the way in which the fibers are processed. In general, those fibers which produce long, strong, and straight cellulose strands are the preferable ones.

Wood pulp is the most important raw material; it constitutes between 50 and 70 per cent of all raw materials consumed. Approximately 119 thousand tons of wood pulp are used by Kalamazoo Valley paper mills during one year.

The wood pulp industry is characterized by four distinct processes which convert pulp wood into wood pulp. These processes are: (1) sulphite, an acid chemical process, (2) sulphate, an alkaline chemical process, (3) soda, an alkaline chemical process, and (4) ground wood, a non-chemical process. The sulphite process produces the most valuable pulp per ton. Sulphite pulp is the leading type of pulp used in the Kalamazoo Valley. Spruce, hemlock, yellow pine, aspen, and jack pine are the most important sources of pulp wood.

Lignin and non-cellulose products in the wood form approximately 50 per cent of the total weight of pulp wood. A yield of fibers of 42 per cent to 45 per cent of the weight of the wood is considered satisfactory.

Since pulp wood is comparatively heavy in comparison to wood pulp, the wood pulp industry is raw-material oriented whereas the paper industry is market oriented.

Wood pulp is obtained from mills located near the forests, principally in the Pacific Northwest, Southeastern and Northeastern United States, Northern Ontario, Eastern Quebec, and British Columbia (Fig. 3). The imports of wood pulp from Finland and Sweden have diminished considerably during the past decade. This is because of unsettled political situation of the world and because of new processes by which aspen and jack pine from Canada can be utilized from sulphite pulp.

The mills of the Kalamazoo Valley receive their wood pulp mainly by direct rail connections with the producing areas. The pulp which is obtained from Scandinavia is transported directly by ship to South Haven, Michigan, from where it is shipped by railroad to the Kalamazoo Valley paper mills. Wood pulp arrives at the mills in large, thin sheets resembling corrugated cardboard.

The Otsego Falls Paper Company, a small book paper concern in Otsego, Michigan, manufactures a portion of its own wood pulp at the site of the paper mill. This company is the only company manufacturing wood pulp in the Kalamazoo Valley. The pulp wood is obtained principally from Canadian sources.

In 1942, the Kalamazoo Vegetable Parchment Company purchased the pulp and paper mill of the Abitibi Company at Espanola, Ontario, and thus became an integrated company with both pulp and paper mills, though the pulp mill is outside our area of concern. Two hundred and fifty tons of sulphate pulp, produced in the Canadian mill daily, are shipped by rail to Kalamazoo.

Paper, like steel and wool, can be reprocessed. Paper stock, a second fiber raw material, is of utmost importance in the paper industry of the Kalamazoo Valley. Paper stock is used with wood pulp, giving added strength to the finished paper. Paper stock is used daily in paper board and book paper mills.

Paper stock comes to the Kalamazoo Valley mills from a radius of approximately two hundred miles (Fig. 3). Waste paper is collected by jobbers in Detroit, Chicago, Columbus, Cincinnati, and Kalamazoo. These men sell the waste paper to the paper companies of the Kalamazoo Valley. Paper stock is shipped to Kalamazoo exclusively by truck. The Allied Paper Company, the largest user of paper stock in the Valley, uses eight million pounds a month.

Upon arriving at the book paper mills, the waste paper is sorted. Paper containing too much clay filler is sent to the paper board mills in the Valley. The remaining paper stock is processed in rotary cookers, bleached, and blended with pure wood pulp before being placed on the paper machines.

A third fiber used in the paper mills of the Kalamazoo Valley is rag fiber. Cotton rags yield cellulose fibers that are about one inch in length.

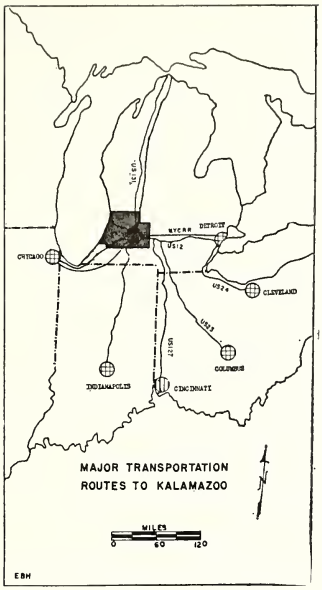

Figure 3

During the early days of paper making in the Kalamazoo Valley, the old rags were collected in Detroit, Chicago, and Kalamazoo by door to door peddlers. These rags were then sold to jobbers who in turn sold them to the paper mills. The use of old rags has declined recently throughout the United States. At the present time there are no old rags being used in the Kalamazoo Valley "rag mills."

The best rags used today come from new cotton scrap material. The shirt manufacturers around Troy and Rochester, New York, and the shoe manufacturers of St. Louis, Missouri, are the principal suppliers of rags (Fig. 3). The Lee Paper Company, the largest of the two "rag mills" in the Valley obtains its rags from these three sources. The rags are shipped directly to the mills by railroad.

After arriving at the paper mill, the rags are sorted and then are dusted in large rotary dusters. After the sorting and dusting, the rags are put through a cooking process to loosen dyes. When this process is completed, the rags are bleached with chlorine and are then placed in beaters which turn them into pulp.

A fourth fiber used in the Kalamazoo Valley mills is cotton linter. Cotton linter is the short cotton fibers left on the cotton seeds after ginning operations are completed. The complete supply of this fiber is obtained from Memphis, Tennessee (Fig. 3).

With the rapid rise of synthetic fibers during the last twenty years, the availability of cotton rags and cotton linter has been seriously curtailed. This has led to a reduction in the number of grades of rag content paper and a concentration in the production of a few high-grade papers.

Another reason for the marked decline in the use of rags in the paper industry is the increased use of sulphite pulp. Improvements in the processing of strong, bright wood pulps have made rags less essential for the fine grades of paper such as bonds and ledgers.

During the last twenty years only one new rag paper machine has been installed in the Kalamazoo Valley. The absence of more new rag paper machines points out the reduced use of rags as raw fiber for paper making.

Water Supply

The abundant supply of pure water has been influential in the location of the paper industry within the Valley. Water is used in large quantities in the manufacturing of paper and allied products. Throughout the Valley are thick deposits of gravels which aid in the storage of ground water. These gravels also serve as natural filters. In addition to the abundant ground water there are surface waters of the Kalamazoo River and Portage Creek (Fig. 5). The majority of paper mills use a combination of ground water and surface water.

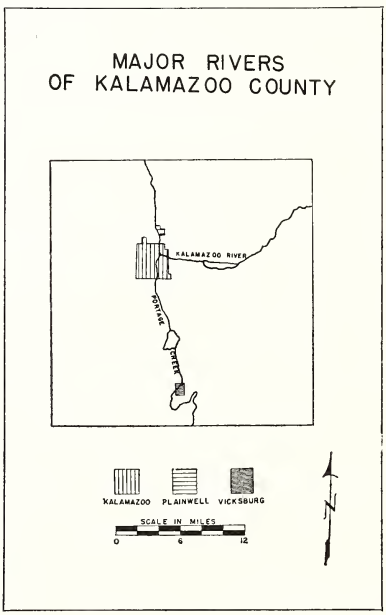

Figure 5

Surface water is used either for power house consumption or after filtering and purification for the paper machines. Surface water used on the paper machines is first pumped from the Kalamazoo River or Portage Creek into coagulating basins. Small amounts of alum are added to the water to expedite the settling of sediments. Following sedimentation, chlorination takes place. In addition to killing bacteria, chlorination controls algae growth, aids in the coagulation of impurities, helps oxidize

manganese, and reduces color by bleaching. After filtration, the water is usually given a treatment with slacked lime to bring the pH value to the desired strength.

The advantage of ground water is that it remains at a constant temperature throughout the year and that the supply remains nearly constant. A constant temperature of water is essential for certain chemical reactions which must take place during the processing of pulp into paper.

Water consumption in each of the Kalamazoo Valley paper mills varies from seven million gallons a day to forty million gallons a day depending upon the size of the paper mill.

Chemicals and Minerals

Although chemicals and minerals play an important role in the manufacturing of paper and paper products, they are less important than water in the location of the paper mills.

Chemicals and minerals used in the Kalamazoo Valley mills are obtained from a variety of sources (Fig. 4). The products are shipped to Kalamazoo by rail.

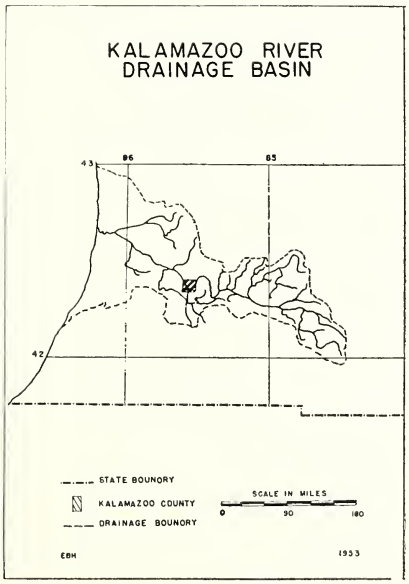

Figure 4

The most important chemical used in the paper industry is chlorine. It is used to bleach both rag and wood pulp as well as to sterilize water. Chlorine is obtained from the Wyandotte Chemical Corporation of Wyandotte, Michigan, and from chemical plants at Niagara Falls, New York.

Casein, used for making coating adhere to book paper, is obtained from Argentina and from the western United States. Before World War II a large amount of casein came from Australia, New Zealand, and

France, but since the war these sources of supply have dwindled, as has the experimental attempt to produce synthetic casein from soy beans in this country. Casein is a protein precipitated from milk and forms the basis for certain plastics and glues.

Starches used in the paper industry are made from a corn starch base. The majority of the starches used in the Kalamazoo Valley paper mills comes from Keokuk, Iowa, by way of Chicago.

Other chemicals and minerals which are used in the paper industry include clay from Georgia, rosin size from Georgia and Tennessee, titanium from New Jersey, lime from Missouri and Indiana, soda ash from Michigan, and coal from Indiana, West Virginia, and Kentucky (Fig. 4).

Labor

Labor is an important locational factor. From a superficial glance at the paper industry of the Kalamazoo Valley, it would appear that the different types of labor used in the paper mills would not be large. However, a closer observation reveals that the types of labor employed are highly diversified—unskilled, semiskilled, skilled, and professional. The eighteen types of employment within the paper mills can be broken down into two major categories: general labor for which the paper industry must compete directly with other industries, and specialized labor which is peculiar to the paper industry. By far the largest number of workers in the paper mills are in the first category. Thus the paper industry has to compete with other industries for its labor supply. Inasmuch as general labor is relatively immobile, the paper industry needs to be so located as to obtain an adequate supply of labor. In order to obtain this supply, the paper industry of the Kalamazoo Valley concentrated in the labor market of Kalamazoo.

Transportation Facilities and Markets

Kalamazoo and its neighboring paper manufacturing communities are located either on or near main highways and railroads which cross the Kalamazoo Valley (Fig. 1).

Kalamazoo is situated midway between Detroit, Michigan and Chicago, Illinois. Highway U. S. 12 and the New York Central Railroad pass through the city from the east to west and connect Kalamazoo with these two cities. Kalamazoo is connected with Grand Rapids, Michigan to the north and with the cities of Indiana to the south by the Grand Trunk Western Railroad, the Pere Marquette Railroad, and by Highway U. S. 131 (Fig. 1). These transportation routes provide easy access to raw materials and efficient means for shipping finished and semi-finished paper out of the Valley into the consuming areas.

The location of the Kalamazoo Valley paper industry with respect to these transportation routes has affected the market for paper. Although the large paper mills sell products to the Kalamazoo market, they are far from being dependent upon it. The excellent transportation facilities of the Valley expand the radii of the market of the paper mills to a national scale.

Conclusion

The paper industry is the dominant industry in the Kalamazoo River Valley. Like most manufacturing concerns, the paper industry has been

influenced by various factors. It becomes apparent that some factors have contributed more influence than others to the location of paper making in southwestern Michigan.

It must not be inferred that the factors discussed herewith have been absolute in determining the location of paper manufacturing in western Michigan. Human choice was in the beginning the most important factor and throughout the history of the paper industry in the Kalamazoo region it has had a decided tempering effect on the non-human factors.

HISTORY OF SCIENCE

Chairman: STEPHEN VISHER, Indiana University

FAY K. DAILY, Butler University, was elected chairman for 1960

ABSTRACTS

Sources of the Executives of Leading Evansville Factories. B. H. SCHOKEL, Aurora, Indiana.—Six months of interviewing in and analysis of 200 factories in Evansville, Indiana was followed by about five months spent in review of literature (including newspapers) in the study of several hundred factories of Evansville, between 1830 and 1930. One phase of this research required an interview with the chief executive of each factory and the circumstances leading to his rise in leadership. Here is reported some of the information concerning fifty of the larger factories as of 1933 compared to fifty of the larger earlier ones from 1830 to 1930. The availabe data indicate that the chief executive was selected from the general office department most often. The sales department ranked second as a source of chief executives, the production division third, the purchasing division fourth; a few rose from the ranks of advertising or public relations.

Major qualifications of these executives were: 1) desire to found a new establishment; 2) the possession of much capital or access to such via wealthy connections; 3) experience, especially in selling or as secretary of an executive; 4) inventiveness, useful in the factory; 5) desire to start independent firm after gain of experience; 6) activity during expansion of a firm or merging of firms; 7) inheritance; 8) nepotism.

Anacardium, A Curious Psychopharmacological Drug of Antiquity. LAWRENCE J. KING, Hastings-on-Hudson, N. Y.—A review of the ancient uses of the fruit of *Semecarpus anacardium* (Anacardiaceae) is presented. This fruit, known by the older botanical name, anacardium, has a reported therapeutic use in the treatment of mental disorders, and in "re-establishing the memory and facilitating perception of ideas." Its usage extends far back into antiquity—having been used in both ancient Arabian and Indian medicine. It reportedly was the "golden acorn" *(Chrysobalanos)* of Galen, and both Paulus of Aegineta and Avicenna and other Arabic physicians were familiar with it. Serapion, Rhases, as well as Avicenna recommended it in mental disease—especially in loss of memory; while it was briefly noted by Myrepsus and Actuarius. A prescription for its preparation has been found in the 17th Century *Pharmacopoeia Augustana*, or Augsburg Pharmacopoeia.

Botanists of the Butler University Faculty (1920-1955)

Fay Kenoyer Daily, Butler University

When Dr. Ray C. Friesner came to teach at Butler University in 1919, botany received only minor attention in the curriculum. However, his dream of a Department of Botany materialized the next year and under his many years of direction flourished and bore fruit.

This history would not be complete without including the lives and works of the alumni, but the enormity of this task is evident by glancing through a bibliography of alumni and staff publications up to 1950. Eighty-one authors are recorded.

The large number of graduates listed in American Men of Science (3) received notice by Victor A. Greulach in 1956 (9). The Butler University Botany Department was mentioned as a part of a small group having outstanding productivity worthy of particular note. He concluded, "There is little doubt but that productivity of this small group of liberal arts colleges as contrasted with the lack of productivity of most other colleges of this type is due to outstanding and inspiring teachers of botany. However, there also seems to be a regional milieu favoring strong undergraduate botany departments and attracting and holding superior teachers."

A discussion of short-term members of the staff including summer and evening class teachers would add a prohibitive length, too; for the following have served the department: Rousseau McClellan, Ferdinand Mehrlich, George Fisher, R. F. Daubenmire, Scott McCoy, Charlotte Grant, Noe Higinbotham, Charlene Coffing, Ina Stanley Fitzgerald, Marjorie McConaha Andrews, Charles Hill, Charles Reimer, Florence Geisler and the author.

It is, therefore, to the members of the regular staff serving between 1920 and 1955 that this account is confined. They are presented chronologically as they joined the department.

Dr. Ray C. Friesner was born in Bremen, Ohio, 1894, to parents of modest means. He was to enjoy his mother only a few short years since she died when he was only six years old. His education was extended to college training even though he found it necessary to help finance it. Not only did he accomplish this, but became an honor student at Ohio Wesleyan University. He was stimulated in botanical study there by Dr. Claude O'Neal. Graduate study was done at the University of Michigan under the direction of Dr. F. C. Newcombe, where a Ph. D. degree was obtained.

The personality and excellent training of this man had been such that the Butler Botany Department soon expanded under his direction after its founding in 1920. Dr. Friesner was thorough with attention to detail whether preparing class notes, teaching, advising or doing research. He was a gentleman, scholar and kind friend. His early interest in research and state academies is seen from the paper appearing in the Proceedings of the Michigan Academy of Science in 1919 (6) and the title of a paper presented at the Indiana Academy of Science in 1920 (7). He joined six state academies.

He became widely known internationally as curator of the herbarium at Butler which now contains around 100,000 specimens and has been named in his honor. Collecting frequently, he added a great many specimens to the collection. His association with a group of plant taxonomists affiliated with the Indiana Academy of Science was especially rewarding and stimulating to him. The John B. Coulter award was presented to him in 1947 for his work as secretary of the State Flora Committee. He served the Academy in numerous ways and was chairman of the Index Committee when the Index of the Proceedings Volumes 1-50 (8) was published in 1948. He made an efficient secretary of the Academy and served as president in 1936. He was made fellow of the A. A. A. S., Indiana Academy of Science and Ohio Academy of Science, and was a member of a number of scientific and honor societies (15).

Many former students will recall with pleasure the field trips taken with him—the dew-washed mornings (for he started early) and the diligent work in the field. Some of these were class excursions, but other trips were taken with associates, staff or graduate students for research purposes. His published works considered cytology, ecology and taxonomy with his work on fern and fern allies and Solidago of Northeastern America probably being the best known. A bibliography is given in a memorial issue of the Butler Studies (14).

Upon the twenty-fifth anniversary of the Botany Department at Butler, a dinner and program were held in Dr. Friesner's honor and an anniversary issue of the *Butler University Botanical Studies* appeared containing papers contributed by the staff and alumni and an historical account of the botany department by Dr. Potzger (13).

In 1947, Dr. Friesner was appointed Dean of the College of Liberal Arts and Sciences at Butler. Other recognitions of ability were the James Irving Holcomb Award from Butler University in 1948 and an honorary Doctor of Science degree conferred upon him by the Ohio Wesleyan University in 1951.

Although his administrative duties were heavy as Dean and chairman of the Botany Department, he was still vigorous in his teaching, research and field work. However, his health began to fail and a heart attack brought an early end to a brilliant career on December 1, 1952.

Dr. Stanley A. Cain was added to the botany staff at Butler in 1924. He was born in Jefferson County, Indiana in 1902. His education led to a B.S. degree from Butler University and an M.S. and Ph.D. degree from Chicago University. Dr. Cain vigorously launched his scientific career at Butler with several early papers on ecological subjects. The *Butler University Botanical Studies* first appeared in 1929 with Dr. Cain as editor, and was later edited for many years by Dr. Friesner. Students and faculty have been afforded by this periodical a wonderful vehicle for publication of their research. Its circulation reaches many libraries over the world.

From Butler, Dr. Cain went to teach at Indiana University in 1931. Later, he taught at the University of Tennessee, Cranbrook Institute and is now teaching at the University of Michigan. His interests include micropaleontology, plant sociology and plant geography with many publications in these fields, the best known of which is probably *Foundations*

of Plant Geography (2). He has received a number of important grants to further his work.

He served the Indiana Academy of Science as editor of the *Proceedings* 1929-1934 and chairman of several committees, and was made a fellow of that society. He has been president of the Tennessee Academy of Science, 1945, and the Ecological Society of America in 1953. He was A. A. A. S. vice-president in 1954 and has held offices in other national societies. Two important honors have recently been accorded Dr. Cain—an award of merit from the Botanical Society of America at the 50th anniversary meeting and an honorary doctorate from the University of Montreal at the IX International Botanical Congress.

His is a truly remarkable career at its prime.

Dr. Charles Mervin Palmer came to Butler in 1925. Born in Chester, Pennsylvania, in 1900, he attended school at Pennsylvania State University for the advanced degrees of B.S. and M.S. He received his Ph.D. degree in 1940 from Indiana University. At Butler University, Dr. Palmer was an excellent teacher and initiated some fine courses in microbiology.

His chief interest is in phycology and his field work has added much to our knowledge of the algae found in Indiana. His field of specialization is in the study of two genera of fresh-water algae—Lemanea and Sacheria. Many of his papers appear in the *Butler University Botanical Studies* and the *Proceedings of the Indiana Academy of Science.* A very useful file of the algae found in Indiana with references to the authors was initiated by him.

Dr. Palmer's activity in the Indiana Academy of Science, of which he is a fellow, has included service on committees, contribution of numerous papers and the press-secretaryship 1942-1947. He is a member of other Academies and scientific societies in this country and others and served as vice-president of the Phycological Society of America in 1953.

As a member of a Friend's Service Unit, he did important work for UNESCO in India and Pakistan 1947-1948. In 1950, Dr. Palmer left Butler to become Head of the Nuisance Organisms Research Unit, Biology Section, Robert A. Taft Sanitary Engineering Center, U. S. Public Health Service, where he has continued his outstanding work. He received an S.E.C. award for developing a special microscope slide for counting algae in water supplies (10). Recently, he published an excellent manual on identification, significance and control of algae in water supplies including some fine color plates (12). A large measure of success is his.

Willard Nelson Clute came to Butler in 1928. He was born at Painted Post, New York, in 1869. His higher education was taken at Columbia University 1896-1899 and the University of Chicago, 1903. He was head of Botany at Joliet Township High School, 1903-1909; instructor of botany at Curtis High School, Chicago, 1910; teacher at Flower Technical High School, Chicago, 1911-1928; Curator of the Herbarium, Columbia University, 1897-1899; and Curator of the New York Botanical Garden 1898-1899. Several other short-term positions were held before reaching Butler in 1928.

Mr. Clute established the Botanical Garden at Butler University the same year he arrived there and worked diligently to plant and care for many unusual and interesting plants. He spent considerable time working

in the herbarium and directed mounting and filing of specimens. His exasperation with the endless changes in rules of nomenclature and the names of plants was well-known.

He often composed short jingles about the students to their delight and he published a volume of poems, *Off the Record,* in 1935. Poems also appear to color his botanical writings.

He is probably best known for his popular approach to botany in teaching and in presentation of his research, such as his books: *Our Ferns in Their Haunts,* 1901, *Swamp and Dune,* 1931, *Fern Allies of North America,* 1905 and revised 1928, and *American Plant Names,* 1923. Most of these as well as the *Fern Bulletin* and *American Botanist* were published by Mr. Clute's own publishing firm. The latter publication was unique, having much of the material contributed by the editor. A list of his publications is given in an excellent article about him written by C. V. Morton (11). Mr. Clute is considered the virtual founder of the American Fern Society and published the *Bryologist, Plant World, Ornithologist and Botanist,* besides the above-mentioned journals.

Upon his retirement from Butler, Mr. Clute became director of the botanical garden at Holliday Park in 1938. His death at 81 years of age in 1950 followed a long illness. Those who knew him well will long remember this colorful friend and will recall his gay banter, keen mind, and the wealth of his scientific writings.

Mabel Esten (Mrs. Sidney R. Esten) served briefly on the regular staff of the Botany Department 1931-1932 and then became an instructor in the Butler University Evening Division in 1932. In later years she again served several years in the day division of the Botany Department. She was born in 1898 at Anderson, Indiana, where she obtained her early training. She received her B.S. degree at Butler University in 1922 and returned to Anderson to teach at Anderson Junior High School. In 1923, she married, and because of her husband's interest in conservation, was stimulated to return to Butler for an M.S. degree in botany. She was then added to the Butler University Botany Department staff.

Although Mrs. Esten has been, first of all, a homemaker for her husband and daughter who are both public school teachers now, she has been an excellent, popular and devoted teacher for many years and has published papers on plant association (4) and chlorophyll therapy (5). She is a member of the Honor Society of Phi Kappa Phi and editor of the *Hoosier Button Box.*

She retired from teaching at Butler University in 1953, but again took a teaching position at DePauw University recently.

Dr. John Ernest Potzger came to teach at Butler in 1932. The son of a Lutheran minister, he was born 1886 in Presque Isle County, Michigan, a northern woods area. He was truly a child of the wilderness which he loved and studied so well. Early training at the Teacher's Seminary at Addison, Illinois, was followed by more than twenty years of teaching at the Emmaus Lutheran School in Indianapolis. He also studied music and, a true scholar, his interests finally led him to take a bachelor's and master's degree from Butler University and a doctorate at Indiana University in 1932 when he was added to the Butler Botanical staff.

He was a thorough and excellent teacher and his enthusiasm and warm personality attracted many students. His frequent field excursions to Mackinac Island with ecology classes were anticipated and enjoyed by many. Considerable field work was done and his prodigious published research has been recorded in a bibliography in the Butler University Botanical Studies (16). He was interested primarily in ecology and paleobotany.

He was a frequent contributor of papers in the Indiana Academy of Science of which he was a fellow. Dr. Potzger served numerous times on committees and was chairman of both the Botany and Taxonomy Sections. He was a member of the Wisconsin Academy of Science, as well as several other scientific societies. He was editor of *School Science* and *Mathematics*, 1940-1953; *Butler Botanical Studies*, 1953-1955; *Central Association of Science and Mathematics Teachers Yearbook*, 1940-1945. He was president of the Ecological Society of America, 1954; vice-president, 1947, and president, 1948, of the Central Association of Science and Mathematics.

Several grants-in-aid for his research were received from the American Association for the Advancement of Science, Indiana Academy of Science and Eli Lilly and Company. He was given the J. I. Holcomb award by Butler University in 1949.

As a member of the President's Committee, he studied the Quetico-Superior Forest in 1949 and in 1952 was invited by Dr. Albert Courtemanche to come to Mont Tremblant Biological Station to direct pollen analysis of bogs of that region under the auspices of the University of Montreal and the Quebec provincial government.

He became head of the Botany Department of Butler University in 1953 after Dr. Friesner's death, and there followed an extremely busy and crowded two years of service. Dr. W. D. Billings (1) summed up this period in his life so well, "He was everywhere and seemingly doing everything . . ." His sudden demise in September, 1955, closed an outstanding career.

Dr. Rex Webster who came to teach in the Butler Botany Department in 1950 and Dr. John E. Pelton who came in 1953 are present members of the staff with Dr. Marion T. Hall as chairman. I leave the promising unfolding chapters of this history in their capable hands.

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The Influence of Quakers on Science in Indiana

M. S. Markle, Earlham College

Since the two largest Yearly Meetings of the Society of Friends have the greater part of their area in Indiana, this denomination has exerted an influence in the state out of proportion to its total membership. Thruout their three hundred year history Friends have emphasized education. Quakers came to Indiana early in the past century, migrating largely from North Carolina, where they found slavery inconsistent with the principles of the Society. At that time the public school system of Indiana was not well developed; so when Friends set up a local meeting and built a meetinghouse, a monthly meeting school quickly appeared beside it. At first there were only elementary schools, but as communities became more stable and the demand for more education developed, a series of Academies, of high school rank, were built up. Some of these lasted for only a short time, but others, such as those at Spiceland, Plainfield, Bloomingdale, Fairmount and Westfield in Indiana and Vermillion Grove, in Illinois, became stable and well-recognized schools. Usually there was cooperation with the public school system and the academy was the only high school in its community. Quaker academies in the east, particularly in New England and the Middle Atlantic States continue to flourish, and some, like Westtown and George School, rank very high; but as the public high schools of Indiana improved, and as the financial burden of maintaining private schools increased, the Friends Academies were laid down, one at a time, in the first quarter of the present century. New state legislation, aimed at private schools, made their continuance difficult; but Friends in the midwest now regret that at least one of the academies was not retained.

These academies acted as feeders for Earlham College, established as a Friends Boarding School in 1847. Thruout its history Earlham College has been outstanding in the teaching of science. Men of broad education, attractive personality and scientific and religious devotion were on the teaching staff thruout their teaching careers and during the formative period of the college. Students interested in science were attracted to the college from the academies, as well as from the public schools.

The second president of Earlham College was Joseph Moore, born at Washington, Indiana. He was on the staff of the college from 1861 to 1905; was president 1869-1883, and remained as professor of geology until 1900 and curator of the museum until his death in 1905. With quiet persistence he built up the college museum, which started in one small room, called the Cabinet. Many of the specimens he secured and prepared himself, prominent among which were the mastodon, the most spectacular exhibit, and the fossil beaver, the most valuable one, and until recently the only existing complete skeleton. The museum became one of the best in the state and the best college museum in the midwest. It has been appropriately named the Joseph Moore Museum, and has recently been more safely and adequately housed in David Worth Dennis Hall, the new science building of the college.

One of the men whom Joseph Moore attracted to the college was Allen D. Hole, born at Bridgeport, Indiana, in 1866, and receiving the B.S. at Earlham in 1897. He became Joseph Moore's successor as Professor of Geology and later as Curator of the Museum. Building upon the foundations laid by Joseph Moore, he developed both department and museum. He became interested in glacial geology. Year after year, small groups of students, of whom I was fortunate to be one, accompanied him in the summer, as he worked out the glaciology of areas of southwestern Colorado in the preparation of his doctoral thesis for the University of Chicago.

He also became interested in the U. S. Soil Survey. So many of his students were attracted to this field that at one time ten of the fifty members of the Soil Survey were Earlham men. Prominent among them were James Thorp, now head of the Department of Geology, Earl Fowler, and the late Mark Baldwin. Allen Hole's son, Dr. Francis Hole, is Assistant Professor of Soils at the University of Wisconsin. Ten years ago a research program on soils, supported by the Kettering Foundation and by personal grants from the late Charles Kettering, has been conducted by members of the present science staff in Geology, Biology, Chemistry and Physics, assisted by undergraduate students. Prominent among the projects has been the investigation of soil organisms, particularly earthworms, and the study of fossil pollen. A detailed geological survey of the Whitewater Valley, particularly as to its glacial history, is in progress.

In Volume I, 1900, of the Proceedings of the Indiana Academy of Science, I find Joseph Moore and David Dennis listed as members. They were charter members, along with many other men whom the Academy has honored. In the Proceedings for 1895, the second year in which lists of Fellows of the Academy are published, David Dennis is listed as a Fellow; in 1896, the name of Joseph Moore appears.

David Worth Dennis was born at Dalton, Wayne County, Indiana, did preparatory work at Spiceland Academy, and was Joseph Moore's student at Earlham. He was a teacher from 1873 until his death in 1916. At one time or another and sometimes simultaneously, he taught biology, geology, chemistry and physics. I have heard him say that he did not occupy a chair, but a settee. As the college grew, he was able to devote his whole time to biology. A student of Strasburger at Bonn, and with his Ph.D. from Syracuse, he attracted many students who went on to medical schools or to the study of pure science.

At a time when the study of biology consisted almost entirely of lectures and the dissection of pickled specimens, David Dennis espoused with enthusiasm the use of "outings," as field trips were called. With the gusto of a Linnaeus he led his students into the field for the study of birds and trees. Really interested students were his pride and joy; but woe betide the slacker or the bluffer. One experience in standing before a large class to reveal his ignorance was real humiliation. He was much in demand as a speaker at teachers' institutes, where he preached the gospel of study out of doors. It was at such an occasion that I first knew him. His little book "One Hundred Lessons about Plants," was widely known. He was an enthusiastic student of birds and a member of the committee of the Academy which set up the Indiana Audubon Society. Among his bird students was Alden Hadley, who was for many years associated with

another Quaker, Gilbert Pearson, on the staff of the National Audubon Society, and whose collection of mounted birds and study-skins now forms an important part of the Joseph Moore Museum.

David Dennis was an ardent photographer and made many lantern slides to illustrate his lectures. With Dr. Charles Bond, of Richmond, who recently died at the age of 102, he bought an elaborate German photomicrographic appartus, on which the two men spent many long evenings.

At the twenty-fifth anniversary banquet of the Indiana Academy of Science, Dr. A. L. Foley, then president of the Academy, said of David Dennis, "There is no man in Indiana who has had more influence upon the teachers of the state, upon the schools of the state; there is no man who has been closer to the hearts of his pupils. There is no man who had had more to do with the development of science in Indiana than has Professor David W. Dennis."

The new science building at Earlham College is appropriately named David Worth Dennis Hall.

Two Quakers have influenced the teaching of chemistry at the college. Dr. E. A. Wildman was head of the department from 1919 until his retirement in 1956, with a special interest in organic chemistry. He was the teacher and inspirer of Wendell Stanley, '26, winner of the Nobel Prize for his pioneer work on viruses, a field in which he is now active at the University of California at Berkeley.

Associated with Dr. Wildman was Dr. Martha Doan, who at the same time was Dean of Women at the College. She is undoubtedly the member of the Academy of longest tenure. I find her listed in the Proceedings for 1896, so she has been a member for sixty-three years. She lives at Westfield, Indiana and retains the quick wit, the vivacious personality and the intellectual keenness which were hers as teacher and dean.

In 1861 the college erected Indiana's first astronomical observatory, with an excellent telescope, which has been in continuous use. Dr. Clifford Crump, '12, has retired from Ripon College and returned to his alma mater to teach mathematics and to use the observatory with students.

Recently in order to ascertain the undergraduate origins of American scientists, the members of the science faculty of Wesleyan University made a survey of American colleges and universities. The index used was that of the male graduates of the years 1924-34 who continued their education to the doctoral level and were listed in American Men of Science. Earlham ranked fourth.

Science flourished at Earlham to a greater extent than in most church-related colleges because of the recognition from the beginning of the fact that there is no discord between scientific education and religion. This came about not so much because of an announced policy as thru the educational contributions of the administrative and instructional staffs of the college, who combined in their own lives and teaching an appreciation of nature thru a knowledge of science and a simple and sincere worship of the Creator. While he was on leave for graduate study at Harvard University, Joseph Moore wrote, "In my pursuit of science may I be constantly inspired by the highest motive—that of learning more of God as He has displayed himself in all that He has made. God is the author of truth and how can we be better employed than in searching into such things as he

has given us the power to investigate. The universe is the work of the divine mind. Since omniscience is one of his attributes, the man who knows the most is in this respect most like his Maker."

The fact that this synthesis of science and religion was recognized by teachers in the Department of Religion, as well as those in science, made it possible for students to go from classes in either department to those of the other without being confronted by the mutual ridicule and antagonism that have characterized these two departments in many institutions. Evolution and "higher criticism" may have troubled some of the patrons of the college, but not the students.

Summary of My Sixty Years in Chemistry

Dr. Frank C. Mathers, Indiana University

There were only four teachers in the Chemistry Department of Indiana University in 1899 when I enrolled. The small numbers of students made possible valuable close personal contacts with the faculty. Mr. Brown got me interested in electrochemistry. Later I had the invaluable experience of work with Dr. Bancroft at Cornell both as teacher and, later, as a very helpful friend.

Electrochemistry is a small field compared to organic, physical, or inorganic. However, it is of vital industrial importance since there is no other way as satisfactory for making many things, i.e. aluminum, magnesium, chlorine, fluorine, etc. and, also, for electroplating.

In War I, I was called to Washington to try to make fluorine for use in poison gases. Since the only known method of preparation was electrochemical, it was assumed that any development would be in that field. This known process was so difficult to operate that no one had ever succeeded with it except a very few brilliant scientists in Europe and only small quantities had ever been produced. We failed with it in Washington. Along with other troubles this method required a low temperature of about —30°C.

The idea was chemically logical that compounds of carbon and fluorine might be prepared by using a graphite or carbon anode in some molten fluorine compound. It was assumed that fluorine would be formed first at the anode and that due to its exceedingly active chemical nature, an immediate reaction would take place forming some compounds with the carbon of the anode. It was, of course, possible that any such compounds might have the desired toxic properties since fluorine is in the same family with chlorine and the toxic war gases were chlorine compounds. Potassium acid fluoride, KHF_2, had been used as one step in the Moissan process and was available in the laboratory. Also, it melted at about 200°C which was a very satisfactory working temperature. Electrolysis of this molten salt very unexpectedly gave free fluorine—the first time it had ever been made outside of Europe. As soon as the method was published, experimenters all over the world began using it in research. Today, a modification is used to make fluorine for one of the essential steps in preparing the atomic bomb at Oak Ridge.

Hitler used it and a modification, in making one of his "secret weapons, a poison gas that would spontaneously set fire to organic material such as clothing."

We never did find a toxic material but the present nerve gas is a fluorine compound that does not require any electrochemical step. This nerve gas is 75 times more toxic than mustard gas and 3500 times cyanide.

Graduate students have usually collaborated in the researches that have been mostly trying to improve the electroplating deposits. It is very necessary to have the electroplates as smooth and free from crystals or roughness or projections as possible. Some metals like nickel, copper, chromium, and others give excellent smooth plates or deposits without

much difficulty, but other metals, like tin and lead, give plates that are masses of loose poorly adhering crystals and great difficulty is encountered in producing plates in a smooth satisfactory form. Small quantities of certain organic substances, from 0.1 to 1 gm. per liter, will overcome the trouble.

The aim of the researches is to find the right organic compounds, but this problem has the added difficulty that a substance that will work with one metal may not work with another metal. These desirable substances have been named "addition agents" and they are absolutely necessary in lead and tin and some others.

Much research had failed to find anything for tin where glue was ineffective although excellent for lead. The problem was solved by using cresol along with glue. No one knows why or how these addition agents work, but they do.

In attempting to electroplate tellurium, it was observed (Papish) that many metals were darkened or given a black color by simple immersion or dipping in the tellurium solution without any electricity. A development from this observation has led to the use of tellurium to produce a so-called "oxidized" silver finish on silverware. This is a misnomer as the silverware is not oxidized at all, but it is colored by a thin film of tellurium or silver telluride which happens to be black. A way (Turner) was finally found for preparing excellent plates or deposits of tellurium.

These happy results from experiments designed for other things could be called "accidents," but the real facts were that all of us were working plenty hard and observing everything.

Some metals cannot be deposited at all from any solution containing water. Non-aqueous solvents are required. It was found (Dr. Blue) that aluminum bromide dissolved in ethyl bromide and benzene gave excellent aluminum deposits.

While attempting to separate or prepare a phenolic compound, said to be present in wood tar, it was found (Discher) that the tar itself in a tin bath would cause the electroplates to be bright and shiny like polished metal. The Tin Research Institute is pushing this commercially, and several companies are using it and tar preparations are on sale. It is worth mentioning that the Institute and other research laboratories as well as Dr. Discher, the discoverer, have not been able to find out what the active material in the tar is or how to separate it from the crude tar. What is being used is just what Dr. Discher recommended in his thesis and publication without any important change.

It has been necessary to choose these few researches since any attempt to talk about the more than 130 publications would be more than can be covered in a single lecture. Samples and some demonstrations of a few can be easily shown to the audience.

Changing Census Concepts of Rural Population in Indiana

JOHN FRASER HART, Indiana University

With the approach of the 1960 Census of Population, and on the Seventy-fifth Anniversary of the Indiana Academy of Science, it seems appropriate to examine the way in which the conception of rural population in Indiana has been influenced by the changing definitions used by the Bureau of the Census, and how these definitions in turn have been affected by changing patterns of American life, especially the effects of the automobile on population distribution.

The United States was essentially a rural nation until the last third of the nineteenth century. New York, then as now the largest city, had only four thousand more people in 1840 than Indianapolis had in 1940, and as late as 1870 only a quarter of the nation's people—and only one Hoosier in seven—lived in a town with a population of 2,500 or more persons. Cities and towns were so unique, in fact, that they received little special attention before the Census of 1870.

The first real distinction the Bureau of the Census made between urban and rural population was almost entirely a by-product of a population density map drawn for the Statistical Atlas published in 1874, on the basis of 1870 data (1). The cartographers realized that a city which occupied only a small portion of a county's area might make the entire county appear densely settled if the city population were included in the computation of density. As a consequence, the population of cities having 8,000 or more persons was excluded from the computations, and these places were shown separately on the maps by graduated circles. It was implied that the remainder of the population was rural, but no data other than density were published for this rural population.

It was soon realized that many places of less than 8,000 persons were essentially urban in character, and in the Census of 1880 separate data were published for places of 4,000 or more. There were still no published data on the rural population, and it was not discussed, although there was an implication that the rural population was merely whatever happened to be left when the urban population was subtracted from the total.

The Census of 1890 is the first in which the rural population was specifically defined. The rural population was the remainder when the population of all cities or compact bodies of 1,000 or more persons was subtracted from the total population, although for comparability with earlier Censuses the term rural was also applied—rather confusingly—to the population outside places of 8,000 or more.

The confusion was resolved, in a sense, in 1900, by using the term "semi-urban" for all persons in incorporated places whose size was smaller than 4,000 persons, which was the new lower limit of the urban population. This was the first Census in which figures representing the rural population were formally published (1).

It is easy to see that these shifting definitions could produce some confusing figures. According to the definition used in 1890, for instance, the rural population of Indiana was 1,488,271, but when the definition

used in 1900 is applied to 1890 data the rural population is almost two hundred thousand persons greater: 1,685,271, of whom 294,654 were semi-urban. Between 1890 and 1900 the semi-urban population increased by some sixty thousand persons, but the remaining rural population gave a hint of things to come by losing a total of 574 persons.

Between 1900 and 1910 Census statisticians had been experimenting with the data collected in 1900, and in 1906 a Supplementary Analysis of the Census of 1900 was published; in this Analysis the lower limit of the urban population was placed, for the first time, at 2,500 persons (1). No specific reasons were given to explain why this figure should replace the former lower limit of 4,000 persons, but it was used in the Census of 1910, again without specific justification, and by the Census of 1920 it apparently had become so hallowed with use that justification was no longer necessary. Today, after having been used in five consecutive Censuses—and six after April 1960—it appears to be well established and accepted, despite the fact that it almost appears to have been "pulled out of the hat" when it was first used. It is herewith suggested, however, that we need additional investigation to discover whether the best minimal population size for urban places is 2,500 persons, or whether some other minimal size is more realistic. (This suggestion recognizes the fact that any distinction between urban and rural areas for Census purposes will be an arbitrary one, and that it will presumably be based on a minimal population size.)

On the basis of a minimal population of 2,500 persons for urban places, the Bureau of the Census has computed the size of the rural population in Indiana for each censal year since 1800, when the total population of Indiana Territory was only 5,641 persons (Table I). The entire population of the state was classified as rural until 1840, when three towns exceeded the 2,500 mark; in order of decreasing size they were New Albany (4,226), Madison (3,798), and Indianapolis (2,692). The combined population of these three towns represented only 1.6 percent of the population of Indiana. The urban population of our state has increased enormously since then, of course, and in 1950 Indiana had 119 urban places with a population of 2,357,196, representing 59.9 percent of the state's people.

The population outside places of 2,500 or more in Indiana has also grown, if not so spectacularly nor consistently as the urban population. The rural population grew from the original 5,641 souls of 1800 to 1,653,773 persons a century later, in 1900. But by 1910 the rural population had declined, and again in 1920, and once more in 1930, although at a decreasing rate. Then between 1930 and 1940 there was an increase, which was roughly equal to the decrease between 1900 and 1910, but the total rural population of 1,540,084 persons in 1940 was more than a hundred thousand less than in 1900. This deficit was more than made up by an increase of 176,672 persons between 1940 and 1950, and in 1950 Indiana's rural population of 1,716,756 persons was the greatest ever recorded.

Long before 1950, however, it had become obvious to students of population that startling changes were taking place in the rural population. Until the First World War the people classified as rural were

TABLE 1

Population of Indiana, Urban and Rural, 1800 to 1950

Year	Total population	Rural population	Rural population as a percentage of the total population	Rural farm population	Rural farm population as a percentage of the total rural population
1950	3,934,224	1,716,756	43.6	667,154	38.8
1940	3,427,796	1,540,084	44.9	812,651	52.9
1930	3,238,503	1,442,611	44.5	808,981	56.0
1920	2,930,390	1,447,535	49.4	902,820	62.3
1910	2,700,876	1,557,041	57.6		
1900	2,516,462	1,653,773	65.7		
1890	2,192,404	1,602,365	73.1		
1880	1,978,301	1,592,090	80.5		
1870	1,680,637	1,432,980	85.3		
1860	1,350,428	1,234,524	91.4		
1850	988,416	943,784	95.5		
1840	685,866	675,150	98.4		
1830	343,031	343,031	100.0		
1820	147,178	147,178	100.0		
1810	24,520"	24,520	100.0		
1800	5,641*	5,641	100.0		

" Includes population of area which became Michigan Territory in 1818.

* Includes population of area which later became Illinois and Michigan Territories.

Source: Various publications of the Bureau of the Census.

almost entirely farmers and their families. Not only did they live in the country, but they worked there, and they were distinctly different from city people. The terms "rural" and "urban," in fact, had far greater connotations than mere place of residence, because each actually signified an entire way of life, a complex of interrelated social and economic characteristics with a distinct set of values. No one then could ever confuse urban and rural people, because they differed so noticeably in their dress, talk, manners, diet, even in their very way of thinking; there was probably considerable justification for the stereotypes of the "city slicker" and the "country bumpkin," with all of their associated characteristics.

These stereotypes began to break down after the First World War, however, and largely because the automobile facilitated greater social intercourse between the city dweller and his country cousin. When the farmer began coming to town more often he found it useful to take on some of the protective coloring of the city man, and he also found it easier to participate in the social and cultural life of the city. It is probable, however, that in the long run the ability of the city man to travel in the country was of far greater importance. At first he came just to visit, and then he talked the farmer into selling him a plot of land on which he could build a house, and then clever real estate developers began to capitalize on the new trend by buying entire farms for subdivision. Without the automobile, of course, this would have been almost impossible, and suburban development might well have consisted largely of well-to-do

homes clustered near stops on rapid transit lines. But with the automobile city workers have been able to penetrate virtually every nook and cranny of the countryside, and some of them live at astonishing distances from their place of work.

The physical transfer of residence from city to country is an important phenomenon, of course, and it is readily apparent, but there seems to have been a less apparent but equally or more important change in values associated with the move. Two children were about all a family could take in a crowded apartment in the crowded city, with little space for play. But out in the country, with plenty of room, it seemed almost a shame not to have another child, and besides, everyone else seemed to be doing it. In 1950, for instance, for every thousand women in the child-bearing ages 20-44, Indianapolis had 480 children under 5 years old but the remainder of Marion County had 605. Comparable figures were 500 for Fort Wayne and 720 for the remainder of Allen County, and similar urban-suburban fertility differentials characterize most of the other cities of Indiana.

The striking changes that were transpiring in rural areas, and especially rural areas near metropolitan centers, led the Bureau of the Census to adopt a new concept in the Census of 1930, when the rural population was divided into those persons who lived on farms and those who did not (1). The rural farm population in 1930 was 808,981 persons, or only 56 percent of a total rural population of 1,442,611. By 1940 the rural farm population had risen slightly to 812,651 persons, but it comprised only 53 percent of a total rural population of 1,540,084. By 1950 the rural farm population had dropped to 668,064 persons, or only 39 percent of a total rural population which had increased to 1,716,756 (or 1,577,028, according to the new definition of urban).

The population classified as rural by the Bureau of the Census is increasingly concentrated in the rural nonfarm category, and an increasingly large proportion of the rural nonfarm population live in suburban areas or in villages of less than 2,500 persons (2). In other words, the rural population is composed, to an increasing degree, of urban people who dwell in the countryside, or in small towns, and many students of population are coming to believe that the traditional system of population classification by residence requires careful reconsideration. It would seem, for instance, that stereotypes of rural and urban have lost whatever validity they may formerly have had, and that the former distinctions associated with rural and urban have lost much of their significance. The farmer is no longer a hick; in fact, he frequently is more cosmopolitan than many city dwellers, and he differs from them primarily in terms of his occupation.

It has been suggested, therefore, that the present classification by residence—into urban, rural nonfarm, and rural farm population—should be replaced by a classification based upon occupation, but this suggestion presents several problems. If a classification of population is based upon occupation, how does one classify the children of a farmer whose wife teaches school? Furthermore, the rural population is now the legal basis for allocation of some Federal funds to the individual states for Agricultural Extension, Agricultural Experiment Stations, and highway con-

struction, among others, and at least six states allocate funds for highway construction at least partially in proportion to the rural population.

It appears to me that the basic structure of the present classification is sound, that the concept of the farm population is a valid one, and that it should be retained, *if* the farm population can be defined more stringently so that it only includes bona fide farmers. The crux of the problem, I submit, is the heterogeneous group known as the rural nonfarm population, and it is here that much more research is needed. Inasfar as I know, there has been little or no investigation of the demographic, social, and economic characteristics of the rural nonfarm population of selected rural areas. Who are these people? Why do they live in rural areas? How are they distributed through the rural area? What do they do for a living? Are they a part of the local community? How do they differ—if at all—from the people who live in town? I believe that the rural nonfarm population of Indiana, and the United States, should be subdivided into its components, but first we need to learn more about the rural nonfarm population in order to understand more surely what those components are.

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Effects of Indiana's Streams and Lakes on Science

STEPHEN S. VISHER, Indiana University

Indiana's streams and lakes notably influenced the development of various sciences as a result of three special conditions. 1) Indiana has relatively many streams and lakes because it possesses a humid climate and because most of it was recently glaciated. Only a tiny fraction of the earth is as rich in rivers and lakes as is Indiana. This richness includes several different kinds of lakes and several kinds of streams as well as a wide variation in the size or volume of streams and in the regularity of stream flow. 2) Indiana was on the frontier of settlement at a time when various scientific studies first became considerable in America. The New Harmony Settlement, established by Robert Owen in 1825, attracted several scientists from Europe who made significant studies of the life of Indiana's water bodies. For example, Thomas Say has been called "the father of American conchology and entomology." 3) Indiana was the home of several especially notable scientists. For example, David Starr Jordan's years in Indiana (1874-1891) resulted in numerous studies of Indiana fishes and in the early training of several men who later became distinguished. Dr. Jordan was exceptionally enthusiastic, and stimulated to higher achievement numerous young men. One of his students, Eigenmann, made special studies of fish and other life of caverns, and attained fame as a pioneer in that field. Other of his students studied insects, birds, and reptiles. These animals are especially numerous along or near streams and lakes. Notable Indiana zoologists and their special interests include B. W. Everman, C. H. Gilbert, and C. H. Eigenmann (fishes); W. S. Blatchley, E. B. Williamson, J. J. Davis and A. C. Kinsey (insects); Everman's study of an Indiana lake, Maxinkuckee, was one of the best early studies of an American lake.

Many kinds of plants are also found in or near bodies of water. The study of plants was greatly stimulated by John Merle Coulter, who was a leader in science in Indiana 1874-1893 (Hanover and Wabash Colleges and Indiana University). He was the second president of the Indiana Academy of Science (following Jordan) and became president of Indiana University when Jordan left for Stanford University. Stanley Coulter, his brother, at Purdue 1887-1926, was highly significant in this state for decades. C. C. Deam's volumes on *Trees of Indiana* and *Flora of Indiana* (1940) won for Indiana leading rank among the states so far as flora are concerned. A large share of the plants discussed in these volumes are found near water.

Indiana's many streams facilitated the study of the geology and paleontology of the state; also, partly by creating exposures of the rocks, and by revealing special conditions along various valleys. Indeed the earlier studies of Indiana geology and paleontology were largely made along streams.

Indiana's streams were so significant in the early years that much of the first sizable Geography of Indiana dealt with their location and depth at high water and low water stages. Most of the early settlers established

their homes close to streams or springs. Many township and county boundaries were partly along streams as was the southern and southwestern boundary of the state. The northern boundary of the state was partly along Lake Michigan.

MATHEMATICS

Chairman: G. N. WOLLEN, Purdue University

KERMIT H. CARLSON, Valparaiso University, was elected chairman for 1960

ABSTRACTS

Symposium: Computers and the Collegiate Mathematics Program. PAUL T. MIELKE, Wabash College.—Financial problems of the small (600-1200) privately endowed liberal arts college make it unlikely that many such institutions will engage actively in the use of computers. The purchase or rental of a computer cannot be justified by its use as a teaching tool. Therefore schools engaging computers must finance them through research or special gifts.

The basic curriculum of the small college (usually consisting of about 18 hours of analysis including differential equations, 6 hours of algebra including matrix algebra, 6 hours of statistics and 12 hours of additional material such as geometry, topology and function theory) offers little possibility for addition of special courses such as numerical analysis or computer programming. However, the opportunities of orienting such courses as statistics, matrix algebra and differential equations toward computer techniques must not be overlooked.

Teachers should seek help actively from the computer manufacturers and machine users in developing the interests of their students through computer-oriented courses and extracurricular activities. Over the last two years at Wabash College an experiment involving study of the IBM 704 has met with some success.

Finally the teacher should be alert to the many opportunities for summer employment which will develop his computer interests and those of his students.

SEYMOUR PARTER, Indiana University.—Most discussions of the computers and the collegiate mathematics program seem concerned with the expansion, or inclusion, of traditional courses in numerical analysis and/or the significance of "programming" and "computer science." Little, if any, attention has been focused on the possible repercussions of the need for more sophisticated mathematics by research workers using computers. As the abilities of the machines become greater the usefulness of many mathematical subjects which are usually considered "high-brow" will become more and more apparent. Consequently, it is reasonable to expect that we will soon see the time when courses in Real Variables, Modern Algebra, Logic, Probability, Orthogonal Polynomials and Functional Analysis are regularly taught in the graduate school to large groups of non-mathematics majors. When such courses are part of the "service" obligations of the graduate mathematics curriculum, we may expect some very interesting changes in the Collegiate Mathematic program.

DR. KAJ L. NIELSEN, Allison Division, GMC.—The influence of computers upon the collegiate mathematics program should be divided into four categories:

I. The effect on the engineering mathematics program
II. The effect on the program for the industrial mathematician
III. The effect on the program for the mathematics teacher
IV. The effect on the program for the statistician.

Let us consider each in turn.

I. In addition to the standard engineering mathematics curriculum the extensive use of the computers in the solution of engineering problems now demands:

a) A course in numerical analysis
b) A course in mathematical modeling of engineering problems
c) A basic course in computer programming with laboratory work.

II. For the industrial mathematician the demands are the same as those for the engineering program plus the addition of

a) An advanced course in numerical analysis
b) A detailed course on a specific computer.

III. For the mathematics teacher the demand is for

a) An elementary course in numerical analysis
b) Enrichment of the present courses by greater emphasis on emperical equations and more detailed study of special functions.

IV. For the statistician the demand is for

a) A course in numerical analysis
b) A course in linear and dynamic programming
c) A course in computer programming with laboratory work.

It is essential that the enlarged program be kept within the mathematics department.

Some Advantages of Riemann-Stieltjes Integration. GREGERS L. KRABBE, Purdue University.—In the course of the last three decades, Lebesgue integration (i.e., integration with respect to countably-additive measure) has assumed a predominant role. However justified this may be, Lebesgue integration is inadequate in some important cases that require Riemann-Stieltjes integration.

Uncertainty and Entropy. J. H. ABBOTT, Purdue University.—The usual information theory concepts of entropy and uncertainty are introduced. Modern conditional expectation is then discussed and applied to conditional entropy and uncertainty. For example, if π is a countable and measurable partition of the space Ω in the probability space (Ω,F,P), and a is a σ-subalgebra of the σ-algebra F, then the conditional uncertainty $U(\pi|a)$ of π given a is defined at $\omega\epsilon\Omega$ by

$$U(\pi|a)(\omega) = -\log_2 P(A|a)(\omega)$$

where A is the unique set in π for which $\omega\epsilon A$, and $P(A|a)$ is some fixed version of the conditional probability of A given a. Some elementary results in information theory are then shown to follow easily using the techniques of conditional expectation.

On Generalized Functions—A Survey. MICHAEL GOLOMB, Purdue University.—The role of improper or singular functions in mathematical

physics and engineering is pointed out. In particular, Green's functions, impulse functions, weak derivatives, weak solutions of partial differential equations, generalized Fourier integrals etc. are discussed. The theories of "generalized functions" or "distributions" of Soboleff, L. Schwartz, Mikusinski, and simplifications due to Temple, Lighthill, Korevaar and others are analyzed and compared. There are four main procedures in the construction of generalized functions:

A. Weak (sequential) completion of the class of continuous functions, C, weak convergence being defined by the use of integrals of the products of these functions by indefinitely differentiable functions with compact supports.

B. Strong (sequential) completion on each compact subset K of the k-th (k depending on K) primitives of the functions in C.

C. Generalized functions ("distributions") as linear functionals continuous on the space of indefinitely differentiable functions with compact supports, with a certain convergence concept (for sequences).

D. Generalized functions as quotients in the field constructed from the linear algebra with no zero divisors of the continuous functions of one variable t vanishing for $t < o$, the product being the convolution product.

A., B., C., lead to equivalent concepts. D. is especially well suited for an operational calculus a la Heaviside.

A New Introduction to the Ideas and Methods of Trigonometry. ROBERT J. THOMAS, DePauw University.—This new mathematical system was developed to illustrate the ideas and methods of trigonometry to college students without using sine's or $\propto$'s which might remind them of triangles and angles (from hearsay or partial courses in high school) and without any possible distracting practical applications. The actual development of this system could also be used on the one hand to illustrate to the teacher one good method of organizing the presentation of trigonometry; or, on the other hand, to illustrate to the student the logical development of a system per se, irrespective of any analogies to trigonometry.

A New Look at Least Squares. RICHARD DOWDS, Butler University.—The modern theory of approximation is having a profound influence on numerical analysis. Not only does approximation theory give new results and methods in numerical analysis, but it also tends to group under one heading a large number of problems that were heretofore disconnected. It is the purpose of this paper to show how approximation theory can be used to bear on the ancient technique of least squares. It is the author's opinion that this new approach is more elementary than the traditional development of least squares.

A Definition for Polynomials on Topological Groups, and Some Examples. F. W. CARROLL, Purdue University.—The following definition is given by Domar: Let f be a real-valued function on a topological group G. Then f will be called a polynomial on G if (P1), (P2), and (P3) are satisfied.

(P1) For each pair x_1, x_2 of elements in G, the set of values $f(x_1 + nx_2)$ $(n = 0, \pm 1, \ldots)$ coincide with the values assumed at the integers by some polynomial on the real line.

(P2) If $d(x_1, x_2)$ denotes the degree of $f(x_1 + n x_2)$ (as a polynomial in n), then $\sup_{x_1, x_2 \in G} d(x_1, x_2)$ is $< \infty$.

(P3) f is continuous.

Proposition 1: Let f be a real-valued function on the m-dimensional Euclidean space R^m, such that f satisfies (P1) and (P3). Then f is an ordinary polynomial on R^m.

Proposition 2: There are real-valued functions on R^1 which satisfy (P1) and (P2) but not (P3).

Proof: Any non-measurable additive function satisfies (P1) and (P2).

Proposition 3: Let C denote the additive group of integers. There exists a real-valued function f on the discrete group C + C such that f satisfies (P1) but not (P2).

PHYSICS

Chairman: MARSHALL DIXON, Butler University

CHARLES S. MORRIS, Manchester College, was elected chairman for 1960

ABSTRACTS

(d,p) Reactions in Bismuth and Uranium.[1] F. R. SWANSON, G. B. HOLM, J. R. BURWELL and D. W. MILLER, Indiana University.—A double-focusing magnetic spectrometer has been employed to observe the energy and angular distributions of proton groups from Bi^{209} targets bombarded by 11-Mev deuterons. The Q value of the most energetic proton group, previously unobserved, is found to be 2.34 ± 0.03 Mev. As the ground-state Q-value calculated from known binding and disintegration energies is 2.38 Mev, this group may represent either the ground-state or a low excited-state transition, or both. Broad but distinct proton groups were also observed corresponding to groups of states in Bi^{210} with mean excitation energies of 0.41, 0.88, 1.5, 2.02, 2.56, 2.81, 3.15, and 4.03 Mev. The observed properties of these groups yield interesting information on the neutron-proton interaction outside a closed-shell core of the atomic nucleus.

Energy Levels in Ne^{22}. M. B. SAMPSON, H. J. MARTIN and D. W. MILLER, Indiana University.—The 21.8-Mev alpha particle beam from the Indiana University cyclotron has been used to excite the $F^{19}(\alpha,p)$ Ne^{22} reaction. The outgoing proton energies have been measured in a double-focusing magnetic spectrometer. A large number of proton groups were seen and could be identified with the Fluorine reaction. Groups were found corresponding to the ground state of Ne^{22} and known states at 1.28- and 3.37-Mev excitation energy. A state found at 4.52-Mev excitation energy was located at 4.9-Mev in earlier work. Additional proton groups indicated previously unknown states in Ne^{22} at excitation energies of 5.18, 5.67, 6.41, 6.88, and 7.48-Mev. All of the energy measurements are ± .040 Mev.

Beta-Gamma Directional Correlation Measurements in First Forbidden Transitions. H. J. FISCHBECK and R. G. WILKINSON, Indiana University.—The energy dependence of the anisotropy coefficient for the first forbidden beta decay and the subsequent gamma-ray has been studied in the cases of Rb^{86} and La^{140}. The measurements were made with a small shaped field 180° beta-ray spectrometer which defined the electron energy and a moveable scintillation gamma-ray detector. In the case of Rb^{86} the anisotropy ranges from + 0.06 at 160 kev to + 0.19 at 630 kev. The values obtained at seven energies in this range are accurate to about 5%. It is hoped that with these more reliable data a theoretical analysis of the results may lead to a knowledge of the matrix elements involved in the decay. In the case of La^{140} the measured positive anisotropy of + 0.12± 0.03

[1] Supported by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.

at 1.67 Mev is to be compared with the theoretical value of + 0.133 prevails for a spin sequence $4^- — 2^+ — 0$. This data together with the results of Langer's shape determination of the high energy beta group makes the spin assignment of 4^- to the ground state of La^{140} unambiguous.

PLANT TAXONOMY

Chairman: SCOTT MCCOY, Arsenal Technical Schools, Indianapolis

WILLIAM A. DAILY, Butler University, was elected chairman for 1960

ABSTRACTS

New County Records for Indiana. SCOTT MCCOY, Arsenal Technical Schools.—Three genera are listed:

Botrychium dissectum Spreng.—a new record for Marion County. Only one plant of the species was found. It was growing in a beech woods near 7350 N. Illinois Street, Indianapolis along with numerous plants of its variety obliquum. The specimen is housed in the Indiana University herbarium.

Liparis lilifolia (L) Richard—a new record for Marion County, Indiana. Several plants were found in a well drained beech woods back of 7350 N. Illinois Street, Indianapolis. Knowing that homes are to be built in the near future, the plants were removed to the wild flower garden, 1120 East 86th Street, Indianapolis 20. Specimens are deposited in the herbaria at Indiana University, Butler University and DePauw University.

Quercus X *Leana* Nutt. Knox County. Specimens have been deposited in the Indiana University, Butler University and DePauw University herbaria.

Variations in the Genus *Tragopogon*. JOAN V. PERSELL, Arsenal Technical High School.—Variations in the genus *Tragopogon* (Compositae) were studied in the immediate areas of Indianapolis and Lafayette, Indiana and from herbarium samples collected from the same areas. The genus *Tragopogon* is represented by three weedy species, *T. dubius Scop.*, *T. porrifolius L.* and *T. pratensis L.* These species are coarse biennial herbs which have infested waste areas, roadsides, fields, and pastures. Each of the three species is rather sharply defined by a combination of specific characters. There is little difficulty in recognizing a given individual. The species differ in habit; in color, in shape, crisping, curling, and indument of the leaves; in color, number and shape of the involucral bracts; in the size of the head; in the relative length of the bracts and ligules; in the color of the ligules; in the shape and relative length of the beak and body of the fruit; in the color of the fruit and pappus.

Wherever any two of the three species grow together hybridization and resulting introgression could be occurring. The number of hybrids found, however, were few. The hybrids showed combinations of certain dominant characteristics derived from the parents involved. The sterility of the hybrids is quite obvious at a glance. In the populations where *T. dubius Scop.* and *T. pratensis L.* were found growing, individuals were found which did not express the characters of the Fl hybrids. Since hybridization and introgression could be occurring, taxonomic difficulties are arising in the effort of accurately defining the species.

Teratology in Trillium Grandiflorum's Floral Organs

Marion T. Hall, Butler University

Introduction

Certain variations in *Trillium grandiflorum* (Michx.) Salisb. may prove important for the investigation of several fundamental biological problems. Some of these variations have been studied for several years by the writer and I shall present some preliminary observations concerning their significance.

Occasionally, in natural populations of *Trillium grandiflorum* there are found large numbers of "mutants" which were lumped together and named *Trillium grandiflorum* var. *variegatum* Smith. Since Smith (1) noted these unusual forms, they have been reported again and again, particularly from Michigan, southwestern Ontario, the Don Valley, Ontario, and the vicinity of Buffalo and Syracuse, New York. Numerous reports of these mutant forms made prior to 1917 have been summarized by Gates (2); later reports by Farwell (3), P. Louis-Marie (4), P. Louis-Marie and R. Giroux (5) indicate the variety of freaks and their persistence in the habitats where they are found. The evidence suggests that these freaks are mostly sterile and should be considered a teratological assemblage deserving no nomenclatural status whatsoever.

These mutants may be roughly grouped into five categories:

1. plants with more or fewer numbers of parts, both reproductive and vegetative, than the usual three per part (whorl);
2. plants with white petals streaked with more or less green tissue (leaf-like petals), with long-petioled leaves or normal leaves;
3. plants with green petals usually with petioled leaves or sometimes no leaves;
4. plants with pink flowers (opening pink) streaked with green tissue and having either petioled or normal leaves;
5. plants with pink flowers (opening pink) mottled or streaked with white and having normal leaves.

In appearance these mutants suggest the condition found in Parrot-tulips where the abnormal behavior in morphology is the result of virus transmission in propagules.

The distribution of the mutants suggests a possibility of virus infection. In southern Michigan they occur in woods of the northern type—in cold woods—beech-maple, white pine, hemlock, yew, wintergreen, etc. They occur again in similar habitats far to the north, e.g., in Leelanau County, Michigan. For this reason it was suspected that the development of mutant patterns may be the result of virus production on a differential basis, since it is well known that cold temperatures (northern climates) favor the production of virus protein in infected organisms creating competition in protein synthesis which affects the production of normal protein and results in an upset in the normal metabolism of the organism. It is thought that *Trillium grandiflorum* normals and abnormals should be

studied and compared, and the factors responsible for the production of the mutants should be determined.

Certain species and even genera of higher plants are considered to be of rather labile consitution and these often contain numerous teratological forms. The nature of the protoplasm of labile species should be studied and understood. Several species of the genus *Trillium*, particularly *T. grandiflorum*, demonstrate this liability. In most cultivated plants teratology is common not only because man selects the unusual but because hybridization, which permits unfamiliar gene combinations, is so universal. The relative precision of homeostatic control is surely weakened under these pressures. Historical relationships between *Trillium* and its relatives *Medeola* and *Paris* may prove most interesting in relation to the teratology in *Trillium* species. The present study was an attempt to discover an agent, a virus, which might be responsible for these teratological variations, while at the same time the proteins of normal and teratological leaves and petals were analyzed.

Normal and teratological plants were collected and kept cold to prevent the denaturing of protein. Leaves and petals were chopped, homogenized, centrifuged at 5,000 r.p.m. for 1 hour. The protein complements were salted out at 0.3 saturated Ammonium Sulphate and 0.6 saturated Ammonium Sulphate. These precipitates were dialyzed, brought to equilibrium with external buffer, and then analyzed in Tiselius electrophoresis.

Electrophoresis photographs were taken at 30 minute and one hour intervals. These photographs show the following:

1. there are three major protein components, A, B, and C in both leaves and petals of normal and teratological plants,

2. the normal petals possess much more of component A relative to B and C than do leaves,

3. the leaves from teratological plants show the same protein components as leaves or normal plants,

4. the teratological petals possess much more of component A relative to B and C; they are almost identical to the leaf components; i.e. these petals are like leaves,

5. there is a suggestion that there may be two peaks at B in the teratological petals instead of one.

There is no clear evidence that the teratology is caused by virus and there is no sharp peak in the electrophoresis typical of viruses. It remains necessary to do further work to establish the presence or absence of virus. It is likely that virus is not involved since its presence would indicate unusual behavior for virus—the production of additional normal protein rather than a foreign virus protein as in the case of most viruses.

At any rate these data show that this teratology is brought about by the presence of leaf protein in greater amounts than normal for certain floral parts in *Trillium*. Additional chloroplast proteins may have considerable determinative effects in changing the morphology of the floral organs. How these additional proteins are elaborated remains to be determined. At least this teratology does not appear to be transmitted through seed; it has no genetic significance, and does not deserve taxonomic status.

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Contributions to the Flora of Wayne County, IV

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A study of three families of flowering plants of Wayne County, Indiana, namely the *Gramineae, Cyperaceae* and *Compositae* was made during the academic year 1958-1959. These families were omitted in previous studies and reports of monocotyledonous and dicotyledonous families. As before, no species are included in the following list unless previously reported by Deam, or now present in the Earlham College herbarium, hence the list is not to be considered complete for the county.

The following list includes 188 species in 73 genera. There are 101 species recorded here which were not included in Deam's Flora of Indiana for Wayne County. It should also be noted that the genus *Aster* has not been studied, or rather the author is unwilling to list *Aster* species for the County at this time. The sequence of genera, and of species within genera, is alphabetical. The nomenclature is in accord with Gray's Manual of Botany, 8th Edition.

A list of species in the three families, *Gramineae, Cyperaceae* and *Compositae* of Wayne County, Indiana (Exclusive of species of the Genus *Aster*)

Gramineae: *Agropyron repens* (L.) Beauv., *Agropyron Smithii* Rydb., *Agrostis alba* L., *Agrostis hyemalis* (Walt.) BSP., *Agrostis perennans* (Walt.) Tuckerm., *Andropogon Gerardi Vitman, Andropogon scoparius* Michx., *Andropogon virginicus* L., *Bromus commutatus* Schrad., *Cenchrus pauciflorus* Benth., *Cinna arundinacea* L., *Cynodon dactylon* (L.) Pers., *Dactylis glomerata* L., *Danthonia spicata* (L.) Beauv., *Diarrhena americana* Beauv., *Digittaria Ischaemum* (Schreb.) Muhl., *Digittaria sanguinalis* (L.) Scop., *Echinochloa crusgalli* (L.) Beauv., *Eleusine indica* (L.) Gaertn., *Elymus riparius* Wieg., *Elymus villosus* Muhl., *Elymus virginicus* L., *Elymus virginicus* L. var. *glabriflorus* (Vasey) Bush., *Eragrostis Frankii* C. A. Mey, *Eragrostis megastachya* (Koel.) Link *Eragrostis pectinacea* (Michx.) Nee., *Festuca elatior* L., *Festuca obtusa* Biehler., *Glyceria striata* (Lam.) Hitchc., *Hystrix patula* Moench., *Leersia oryzoides* (L.) Sw., *Leersia virginica* Willd., *Lolium perenne* L., *Muhlenbergia brachyphylla* Bush., *Muhlenbergia frondosa* (Poir.) Fern, *Muhlenbergia mexicana* (L.) Trin. *forma ambigua* (Torr.) Fern., *Muhlenbergia racemosa* (Michx.) BSP., *Muhlenbergia Schreberi* J. F. Gmel., *Panicum clandestinum* L., *Panicum dichotomiflorum* Michx., *Panicum Gattingeri* Nash, *Panicum lanuginosum* Ell. var. *fasciculatum* (Torr.) Fern., *Panicum philadelphicum* Bernh., *Paspalum ciliatifolium* Michx., var. *Muhlenbergii* (Nash) Fern., *Phalaris arundinacea* L., *Phleum pratense* L., *Poa annua* L., *Poa compressa* L., *Poa sylvestris* Gray., *Setaria glauca* (L.)

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Beauv., *Setaria verticillata* (L.) Beauv., *Setaria viridis* (L.) Beauv., *Sorghastrum nutans* (L.) Nash., *Sorghum halepense* (L.) Pers., *Sphenopholis intermedia* Rydb., *Sporobolus neglectus* Nash., *Triodia flava* (L.) Smyth.

Cyperaceae: *Bulbostylis capillaris* (L.) C. B. Clarke., *Carex amphibola Steud.* var. *turgida* Fern, *Carex artitecta* Mack., *Carex blanda* Dewey, *Carex Careyana* Torr., *Carex cephalophora* Muhl., *Carex communis* Bailey, *Carex conjuncta* Boott., *Carex convoluta* Mack., *Carex Davisii* Schwein and Torr., *Carex digitalis* Willd., *Carex Frankii* Kunth, *Carex granularis* Muhl., *Carex Grayii* Carey, *Carex grisea* Wahl., *Carex hirsutella* Mack., *Carex hirtifolia* Mack., *Carex hystricina* Muhl., *Carex Jamesii* Schwein, *Carex laevivaginata* (Kükenth) Mack., *Carex lanuginosa* Michx., *Carex laxiflora* Lam., *Carex leptalea* Wahl., *Carex lupuliformis* Sartwell, *Carex lupulina* Muhl., *Carex lurida* Wahl., *Carex pensylvanica* Lam., *Carex prairea* Dewey, *Carex rosea* Schkuhr., *Carex Shortiana* L., *Carex sparganioides* Muhl., *Carex stipata* Muhl., *Carex suberecta* (Olvey) Britt., *Carex trichocarpa* Muhl., *Carex typhina* Michx., *Carex vulpinoidea* Michx., *Carex Wildenowii* Schkuhr., *Cyperus esculentus* L., *Cyperus flavescens* L. var. *poaeformis* (Pursh) Fern., *Cyperus rivularis* Kunth, *Cyperus strigosus* L., *Dulichium arundinaceum* (L.) Britt., *Eleocharis calva* Torr., *Eleocharis obtusa* (Willd.) Schultes, *Rhynchospora capillacea* Torr., *Scirpus americanus* Pers., *Scirpus atrovirens* Muhl., *Scirpus lineatus* Michx., *Scirpus validus* Vahl.

Compositae (Excepting Genus *Aster*): *Achillea Millefolium* L., *Actinomeris alternifolia* (L.) DC., *Ambrosia artemisiifolia* L. var. *elatior* (L.) Descourtils, *Ambrosia trifida* L., *Antennaria fallax* Greene, *Antennaria plantaginifolia* (L.) Hook., *Anthemis cotula* L., *Arctium minus* Bernh., *Artemisia annua* L., *Bidens bipinnata* L., *Bidens cernua* L., *Bidens comosa* (Gray) Wieg., *Bidens frondosa* L., *Bidens vulgata* Greene., *Cacalia atriplicifolia* L., *Chrysanthemum leucanthemum* L. var. *pinnatifidum* Lecoq & Lamotte, *Cichorium Intybus* L., *Circium arvense* (L.) Scop., *Circium discolor* (Muhl.) Spreng., *Circium vulgare* (Savi) Tenore., *Eclipta alba* (L.) Hassk., *Erigeron annuus* (L.) Pers., *Erigeron canadensis* L., *Erigeron philadelphicus* L., *Erigeron pulchellus* Michx., *Erigeron strigosus* Muhl., *Eupatorium maculatum* L., *Eupatorium perfoliatum* L., *Eupatorium purpureum* L., *Eupatorium rugosum* Houtt., *Galinsoga ciliata* (Raf.) Blake., *Gnaphalium obtusifolium* L., *Gnaphalium purpureum* L., *Grindelia squarrosa* (Pursh) Dunal., *Helenium autumnale* L., *Helianthus annuus* L., *Helianthus decapetalus* L., *Helianthus giganteus* L., *Helianthus grosseserratus* Martens, *Helianthus microcephalus* T. & G., *Helianthus strumosus* L., *Helianthus tuberosus* L., *Heliopsis helianthoides* (L.) Sweet., *Inula Helenium* L., *Krigia biflora* (Walt.) Blake., *Lactuca biennis* (Moench) Fern., *Lactuca canadensis* L. var. *obovata* Wieg., L. canadensis L. var. *latifolia* Ktze., *Lactuca floridana* (L.) Gaertn., var. *villosa* (Jacq.) Cronq., *Lactuca scariola* L., *Polymnia canadensis* L., *Prenanthes alba* L., *Prenanthes altissima* L., *Prenanthes racemosa* Michx., *Rudbeckia hirta* L., *Rudbeckia laciniata* L., *Rudbeckia speciosa* Wenderoth var. *Sullivantii* (Boynt. & Beadle) Robins., *Senecio aureus* L. var. *gracilis* (Pursh) Britt., *Senecio obovatus* Muhl., *Silphium integrifolium* Michx., *Silphium perfoliatum* L., *Silphium terebinthinaceum* Jacq., *Silphium trifoliatum* L.,

Solidago altissima L., *Solidago caesia* L., *Solidago canadensis* L., *Solidago canadensis* L. var. *gilvocanescens* Rybd., *Solidago flexicaulis* L., *Solidago gigantea* Ait. var. *leiphylla* Fern., *Solidago ohioensis* Riddell, *Solidago patula* Muhl., *Solidago nemoralis* Ait., *Solidago Riddellii* Frank, *Solidago rugosa* Mill., *Solidago uliginosa* Nutt. var. *linoides* (T. & G.) Fern., *Sonchus arvensis* L. var. *glabrescens* Guenth., Grab. & Wimm., *Sonchus oleraceus* L., *Tanecetum vulgare* L., *Vernonia altissima* Nutt., *Xanthium italicum* Moretti, *Xanthium pensylvanicum* Wallr.

PSYCHOLOGY

Chairman: CHARLES C. JOSEY, Butler University

D. C. COLBURN, Manchester College, was elected chairman for 1960

ABSTRACTS

Psychology, Mass Communication Media and the Public Mind. EUGENE E. LEVITT, Indiana University Medical Center.—Despite its newness as a scientific discipline, professional psychology has a great deal to offer to the public which could be of value. Much of this consists of information relative to many specific topics on which the public is either uninformed or misinformed. As nearly as we can tell, the public has shown great interest in matters psychological and appears receptive to information. Many surveys show that the public is generally either ignorant or misinformed about these matters. There seem to be two reasons for this. Psychology as a profession has largely neglected the area of public information. We have not seen it as part of our professional occupation to communicate with the lay public. This does not seem to reflect a broad reluctance on our part to speak up, although we acknowledge that it is frequently difficult to present our findings without dangerous oversimplification. Rather, it is that we sit in our offices waiting for the public to come to us and ask. Too often, this does not happen, in most instances because the public does not seem to know whom to ask. What has happened is that unqualified, irresponsible, opportunistic, and sometimes downright dishonest and unethical individuals have pre-empted the role of the legitimate psychologist in presenting psychological material to the public. The result has been a poisonous spawn of misinformation and misconception which is potentially harmful to the public. The mass media of communication—newspapers, TV, radio and magazines—have played a key role in the transmission of this information to the public. This has been in part because the leaders of the mass media, like other laymen, simply do not know who is a reputable psychologist and who is not. But it also appears that the media have been selfishly materialistic. The argument has been that the public wants the information and so it must be given to them, regardless of who gives it. The mass media apparently see themselves as reflecting public interest but not as responsible molders of it. Any potential solution presents a complex problem with many critical aspects.

Children's Concepts of God. OLIVER E. GRAEBNER, Valparaiso University.—In 1954 the author undertook a study of the concepts of God in children for the Lutheran Education Association of Chicago. The study was an attempt to ascertain what ideas children have about God and how these ideas are related to personal factors such as home background, religious experience, age, maturity, and intelligence.

The basis for proceeding with this study was the assumption that children have ideas about God, ideas which reflect the culture miliou, and

that these concepts can be expressed by the child verbally, pictorially, musically, artistically, or by combination of several of the above.

The author rejected the forms of investigation used by Patton, Harms and McDowell in their respective studies of children's concepts of God because their fixed terminology and frame of reference hindered the free response on the part of the child. For this study a projective technique with pictures and questions was used. A series of thirty-eight original non-religious pictures were drawn portraying incidents common to American life. The drawings depicted situations related to attributes of God, situations in life which would involve God's help, knowledge, or regard for men. Combined with the pictures were questions giving the child an opportunity to relate God to the situation and thus disclose for the examiner some of his concepts of God with a minimum of direction by the examiner or restriction of the subject.

This is a pilot study and the report deals only with the preliminary phases of the project. Conclusions are as follows: 1) Through the question-picture technique the examiner learns how children in the age group 5 to 13 years think about some aspects of God and God-man relationships. 2) Children of all ages affiliated with an established church or church-related school reflect general acceptance of attributes to be accorded God. 3) Their reasoning varied from literal acceptance of a religious reference to logical deduction. 4) There was a surprising uniformity of responses. 5) Older and more intelligent children replied much the same as younger and less intelligent children. Limitations of the study are recognized.

Panel Discussion: Religion and Mental Health. CHARLES G. MATTHEWS, Fort Wayne State School.—Panel discussions titled "Religion and Mental Health" suggest the further title, "Religion, Scientific Psychology and Mental Health." The present paper was concerned with some implications of this latter title. A fundamental shift in attitude towards mental health from a judgment regarding the presence or absence of neurotic and psychotic symptomatology to a concern with broader issues of self-actualization, life goals, and what Sullivan called "difficulties in living" has blurred the roles, responsibilities and respective areas of competency of the clergyman and the behavioral scientist. A brief historical survey was made of an agreement-disagreement gradient between the two disciplines in their assessment of their joint object of concern—human behavior—and several positive and negative consequences of a rapprochement between humanistic religion and humanistic psychology were considered. The premise that the goals of either religious affiliation or psychological counseling are necessarily anxiety reducing ones was also explored, as was the question of the therapist's values, or presumed lack of them, in psychotherapy. A plea was made for mutual tolerance and patience with what seems to be increasing uncertainty regarding our definitions of man, and of the attributes and classes of behavior we want to label as human.

The Relations between the Empirical and the Philosophical Study of Man

Msgr. John J. Doyle, Marian College

It is desirable that there should be a "desegregation of knowledge" among the students of the several branches of natural science, including psychology, but this is by no means easy to accomplish, both because of the degree of specialization necessary to achieve competence in any one of them and because of the diversity of objects with which these fields of study deal.

It is just as desirable and perhaps even more so that segregation between the empirical sciences as a whole and philosophy should be done away with. The difficulty in this case is vastly greater, for besides the two obstacles that stand in the way of communication between physicists and psychologists, between chemists and anthropologists, there is a diversity of method between the activities of the student of the natural sciences and the one that seeks to know philosophically. The former investigates primarily by an inductive method that seeks to establish generalizations that will account for, or imply, the facts that observation discloses. The latter endeavors to order knowledge deductively by scrutinizing propositions that seem to him to be certain in order to discover what is implied by them. The scientist seeks to know how things are; the philosopher tries to find out how they must be or how they can be.

The difficulty is compounded when the philosopher concerned is an adherent of a realistic philosophy, such as scholasticism. The method of the logical positivist, which is akin to that of the inductive or experimental scientist, has a natural appeal to the practicer of such a science. The logical positivist is willing to be silent until the scientist has spoken and then, as has been said, to tell him what he means. The realistic philosopher, including the scholastic, insists upon speaking about the very same things that the physicist or the psychologist deals with, and often comes up with answers to the questions proposed that at least seem to be in contradiction to the answers of the physicist or the psychologist. Perhaps one reason for this seeming diversity is a difference in vocabulary; the same words sometimes stand for quite different concepts in the propositions of the philosopher from those they stand for in the propositions of the scientist. It is altogether likely that the differences are often deeper than this, but the lack of a common nomenclature is a barrier to any understanding between the two groups.

It may very well be that logical positivism does form "the correct philosophical framework" and still that it is not the sole means of acquiring knowledge of the world and, as in the present discussion, of man. The methods of realistic philosophy, which purport to have means of acquiring a certain and not merely a tentative knowledge of some aspects of the world and of man, ought to be understood at least by the practicers of the empirical sciences, just as the methods of the empirical sciences, including the presuppositions of logical positivism, ought to be understood by those that seek to explore reality by means of philosophy by another method.

Some propositions about which there could very well be disagreement between the psychologist that works within the frame of reference of logical positivism and the scholastic psychologist are the following:

The so-called laws of thought, contradiction, identity, excluded middle.
Every event has a cause.
Everything moved is moved by another.
Every agent acts for an end.
Man enjoys freedom of choice.
All men are created equal.
All and only rational beings have rights.
The human personality has absolute value.
Good is to be done and sought after, evil is to be avoided.
Man is a political animal.
All men by nature desire to know.

The exposition of the meaning of these propositions will not of itself convince anyone of their truth. But it would be beneficial if those that practice the empirical sciences should understand what the scholastic philosopher, who also considers himself to be a student of science, means when he enunciates such propositions, just as it would be a happy day when the philosopher should take pains to understand what the scientist is talking about. Conflict between these methods of study antedates modern times; it antedates the time of Galileo, and goes back to the time of Socrates and the atomists. Perhaps this conflict is irresolvable by the human intellect. It can very well be that no man is capable of seeing all aspects of reality in their entirety. As someone recently wrote: "Only God need know explicitly the connection between all possible faces of truth; for us they will always remain, to some extent, mysteries." (1) If this is so, however, it is not a reason why we should be deterred from trying, within the limitations imposed upon us as creatures, to come at least a little closer to mutual understanding, any more than we should be prevented from seeking to know as much as we can in our own fields by the realization that we cannot know everything about anything.

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Value and Psychology

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Control of a Science by Social and/or cultural values is an unacceptable condition. Unified science, by definition, is to be culturefree. Universality in the applicability of facts from the body of reliable knowledge comprising science is necessary. Dr. Charles Morris (1), writing in the "International Encyclopedia of Unified Science," states the following: "The incorporation of the mathematical method within the empiricist temper and the break-down through experimentation of the dichotomy between theory and practice is discernible in the Hellenistic period and the late Middle Ages. It becomes clearly evident in Galileo, reaching a definite expression in Newton. By the late 17th century the great scientists, whatever their philosophical differences, have found a place within scientific method for careful and systematic observation, mathematical theory and experimental practice. Since that time, no fundamental change in the conception of scientific method has taken place, and science has reaped a rich harvest from its attitude of mathematical experimental empiricism."

Dr. Morris does not stop here. After pointing out that science walks on three legs, theory, observation and practice, he goes on to make the following statements. "It is clear that any adequate account of science must take account of the psychological, methodological and sociological aspects of scientific practice. It should be clear that practice in all three senses of the word is not an unessential factor added to the theoretical and empirical aspects of the scientific enterprise, but an equally essential factor, since, at the minimum, confirmation is a concept which contains irreducible pragmatical features. If this is so, it would be well for scientists to become fully aware of this factor of practice, and, in becoming aware of it, to assume the entailed responsibilities. The same point may be given an alternative formulation in terms of the notion of value. It is often said that science gives only facts and has nothing to do with values. There is an element of truth in such a statement, since the pragmatical factor in language cannot be reduced at a given moment to the empirical, and since life is more than knowledge. But this is hardly the usual import of this statement, which is often made against a background which involves a sharp distinction between the natural sciences and the sociohumanistic sciences."

Currently, it would appear that psychology is beginning to manifest the assumption of the responsibility linked with "practice." First, with the rise of professionalism in psychology, values in a way have become important. Let me call your attention to the publication by the American Psychological Association entitled "Ethical Standards of Psychologists." (2) In this sense, value and psychology interact. More importantly, however, the practice of psychology has, and is, bringing intense pressure upon this science from the standpoint of scientific evaluation of behavior and values. As recent as September, 1959, a sharp, dramatic expression of values and their impact on behavior was manifested—namely at the American Psychological Association meetings in which a group of learned scien-

tists discussed "sin." In addition to coincidentally serving to give the "rat psychologist" a symbolic shock treatment, it emphasized the apparent need in psychology for a scientific concern over good, bad, right and wrong.

Hopefully, a science of behavior has as its ultimate goal the human being as its target. Prediction, control and understanding of human behavior would appear a rational scientific goal. At this point in our development, values would seem to be becoming extremely important insofar as the content of our science is concerned. By logical reduction, we can trace directly to the cause of why we must talk about sin at a meeting of scientists by a simple glance at theory. Kurt Lewin (3), in his "Topological Psychology," talked in terms of the person and his life space, the life space being made up of the external situation (the environment) involving the geographic or physical environment and the socio-cultural environment.

Clearly, a large part of the person's psychological field, when viewed as a dynamic on-going process, involves socio-cultural factors. Socio-cultural factors are permeated with good, bad, right and wrong. To understand, to predict and control the behavior of the person in a life space would imply systematic acquisition of facts (science) which have to do with values mediated by a part of the overall psychological field.

Freud (4) is a historical figure who in his theory of personality placed great emphasis on values. He called that aspect of personality mediating values the super-ego. Recognizing its importance to human behavior, he established certain principles upon which his "scientific psychology" was practiced in the analyst's office. Gordon Allport (5) also talked in terms of values, stating that character is "personality evaluated," although he does not pursue this direction assiduously in his theory of personality structure.

As far as the writer's knowledge is concerned, there do not appear to be any systematic or programatic approaches to the area of values and behavior. For some reason, psychologists have not generally concerned themselves with this part of the psychological field, perhaps feeling that this is the province of sociology, or cultural anthropology, or theology or philosophy.

Alfred Kinsey (6) is an example of an individual who imposed the scientific method on the study of sexual behavior in the male and female. From this work have come many suggestive hypotheses with regard to the relationship between sexual activity and certain value sectors in our society. This type of programatic yet somewhat actuarial data collecting would seem quite significant from the standpoint of shedding light on values in our culture enshrouding sexual behavior and the actual normative behavior of adults.

Eric Fromm (7), for example, attempts to throw some mild light on conflicts within personality, and cultural conflicts. This very small bit of information advanced by him is quite significant. He feels there is conflict within our culture based on the Christian value of "turning the other cheek" and another cultural value of being aggressive, extrovertive, and dominant.

Dr. Abraham Maslow (8), in his book "Motivation and Personality," talks about self-actualizing people (these are good, healthy people) and

in reporting his researches states that there is a relationship between values and self-actualization. He states, for example, "A firm foundation for a value system is automatically furnished to the self-actualizer by his philosophic acceptance of the nature of his self, of human nature, of much of social life, and the nature of physical reality." These statements clearly are loose, very molar, and have limited generalization or applicability.

These are some symbolic psuedo-pods existing in our field. However, I submit that there should be increasing rigor and that we begin to use scientific procedures in order to approach this problem of values within our culture and how they relate to man's behavior as we study him as an object.

Some Suggestions:

First, we should attempt systematically to classify values dealing with good, bad, right and wrong. Perhaps classification might be as follows:

(a) Those values that are mediated by the religious component of our culture.

(b) Values that are mediated by the civil component of our culture, (e.g. paying taxes, civil rights, etc.)

(c) Values that are linked with our society, such as making money, doing good for the underprivileged, etc.

Some form of classification might provide the beginning point, with an attempt to establish hierarchies.

Second, we might attempt to classify consistencies within our culture and inconsistencies. We can focus culturally determined conflicts at the value level, conflicts due to cultural unintegration.

Third, more sharp, clear-cut studies could be conducted in order to understand the ontogenetic processes linked with the conscience structure or the super-ego. Further, studies should be designed to explore the area of change that takes place within the conscience structure within the overall personality organization. This has been done, for example, in the field of interest measurement and has met with some degree of success.

Fourth, we might begin to ask questions and to design studies to ascertain the conditions under which learning takes place with regard to values. In addition, to explore the nature of the motivation operating at those times when critical learning is being experienced. Continuation of studies, very spotty insofar as current knowledge is concerned, which explore the relationship between perception and values would seem extremely fertile. McGinnes (9) and Bruner (10) have done some work in this area.

Fifth, an attempt to establish norms wherein one sets up limits; for example, does one group of adults have a different norm for a given value from another.

My thesis is that values are a part of the content of psychology. We would seem deficient in our acquisition of reliable data.

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SOIL SCIENCE

Chairman: CARL W. GUERNSEY, Purdue University

STANLEY BARBER, Purdue University, was elected chairman for 1960

ABSTRACTS

Possibilities for Increasing the Recovery by Corn of Band Applied Phosphate Fertilizers. A. J. OHLROGGE, Purdue University.—The low recovery, often less than ten percent, of band applied fertilizer is widely recognized. Factors necessary for efficient nutrient uptake are discussed. The plant availability of present day fertilizers are poorly matched to the needs of the crop. It is suggested that delayed availability, accomplished through the use of granule coatings of varying solution or decomposition rates, may better fit availability to need and thereby increase fertilizer effectiveness.

Effect[1] of Iron, Aluminum and Humic Acid on Phosphorus Fixation by Organic Soils. J. E. LARSEN, G. F. WARREN, and RUBLE LANGSTON, Purdue University.—Studies were conducted comparing the effects of iron, aluminum, and humic acid on phosphorus fixation in two organic soils which had undergone different degrees of decomposition. It was shown that organic soils fix phosphorus similarly to other reported phosphorus fixing systems. Iron and/or aluminum additions increased phosphate fixation while humic acid resulted in an apparent negative absorption. Further, humic acid prevented absorption of phosphorus in the presence of limited quantities of iron and aluminum.

In recent years many studies have been conducted on the various factors affecting phosphorus fixation in inorganic soils. Hemwall has reviewed these quite adequately. However, such studies have not been conducted on organic soils.

It has been shown previously that large differences exist in the capacities of organic soils to fix phosphorus into a form unavailable to plants and insoluble in water. The ability of organic soils to fix applied phosphorus increased with the length of time the soil had been cultivated. Further, it was shown that the retention of applied labeled phosphorus in leaching studies was closely correlated with the sesquioxide content of the soils and their apparent degree of decomposition. It can be seen that an understanding of the nature of this fixation would be of considerable practical importance.

In this investigation, the effects of iron, aluminum, and humic acid were studied on the fixation of applied labeled phosphorus in two organic soils at different stages of decomposition.

The Influence of Surface Applied Mulches upon Soil Condition and Environment. RONALD B. TUKEY and E. L. SCHOFF, Purdue University.—Mulches which varied in both rate of decomposition and texture were

[1] Journal Paper No. 1250. Purdue University, Agr. Exp. Sta.

applied to the surface of Tippecanoe loam soil in small replicated plots and maintained for five years. Soil samples taken from these plots at the end of this time showed that in comparison with soils under clean cultivation and bluegrass sod, mulched soils were not significantly different in pH, lime requirement or in the availability of calcium and magnesium. However, readily available phosphorus and potassium as well as weakly available were significantly effected by mulches. Increases in the availability of phosphorus were significant only for the loose textured mulches such as legume hay, straw and glasswool while increases in potassium were significant for all mulches excepting sawdust. Soils under mulches were found to be lower in temperature during the summer and higher in moisture. Mulched soils were neither significantly higher in the number of bacteria nor fungi nor were they significantly different from cultivated soils in total pore space. Mulched soils were typically lower in oxygen and higher in carbon dioxide than cultivated soils with the finer materials associated with the lowest oxygen and highest carbon dioxide content.

How Serious Is Phosphorus Fixation on Indiana Soils?

Stanley A. Barber

When soluble phosphorus fertilizers are applied to the soil they react with the soil to form rather insoluble iron, aluminum and calcium phosphates. This reaction is called fixation. Because of this fixation, phosphorus fertilizers have been applied so that a minimum of soil contact occurs. Consideration of phosphorus fixation was probably important when low amounts of fertilizer were applied. Comparisons of 10 to 15 lbs. of phosphorus (P_2O_5) applied as a row application with a similar amount applied broadcast for corn has frequently shown the row application to be more effective in increasing corn growth. This relationship may not necessarily be true at higher rates of application.

Two phosphorus fertilizer experiments conducted in recent years allow a comparison of method and time of application of the phosphorus on the residual availability of the phosphorus to corn. The residual effects of phosphorus applications were determined on the basis of the phosphorus content of the corn leaf at the tasseling stage. In an experiment at the Purdue Agronomy farm, at Lafayette, on Raub silt loam, the total phosphorus applied in the period 1952 to 1958 was correlated with the phosphorus composition of the corn leaf in 1958, Figure 1. The phosphorus was applied both as broadcast and row applications to a corn, soybean, wheat, and hay rotation. The amounts, method of application and time of application of the phosphorus on these plots is shown in table 1. The significant relationship here, is that the availability of phosphorus was apparently not affected by the time or method of application but only by the amount applied.

Since results on one location may be influenced by the soil and by the particular manner of fertilization, a second experiment was investigated. This experiment was conducted on a Bedford silt loam near Salem, Indiana.

The correlation of the total phosphorus applied from 1953 to 1958 with the phosphorus content of the sixth corn leaf is shown in figure 2. In this case all broadcast applications were made when the experiment started in 1953 and no phosphate has been broadcast since. Row applications were made for corn and wheat. The amounts applied and times of application for each treatment are shown in table 2.

The results of these two experiments indicate that where large phosphorus applications (more than 25 lbs. P_2O_5 per acre per year) are used, the time and method of application are not of great importance in determining the residual benefits of phosphorus fertilizers. The soils in both cases had a pH of 6.5 to 7.0.

This is an important consideration in phosphorus fertilization since, if fixation is not a problem, a farmer can apply most of his phosphate once every three or more years and use very small amounts as row fertilizers. The possibility of doing this enables a farmer to use bulk fertilizers rather

Journal Paper No. 1520 Purdue University Agr. Exp. Sta., Lafayette Ind. Contribution from the Department of Agronomy.

than bagged fertilizer. He can also have it custom applied if he wishes so that he eliminates or reduces the labor and time involved in applying the fertilizer when he is planting the crop.

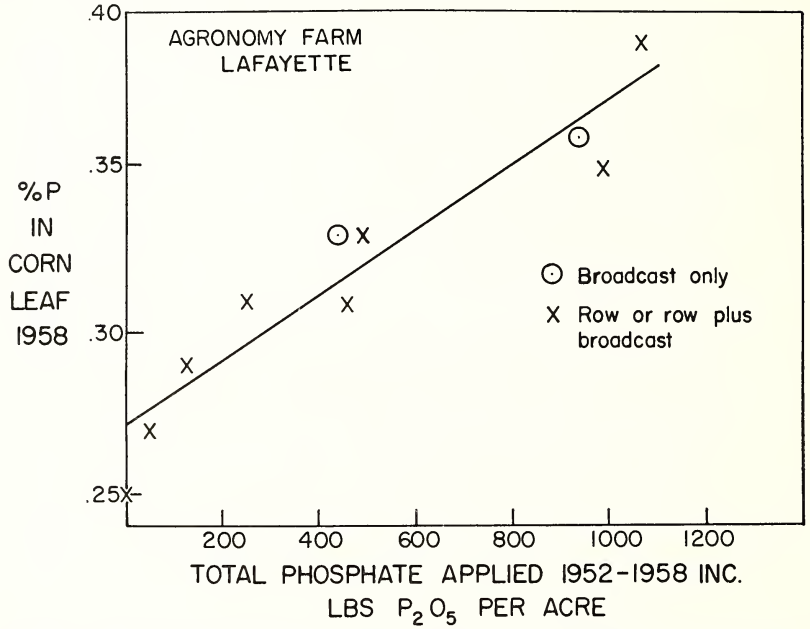

Figure 1. The relation between phosphate applied from 1952-1958 inc. and percent phosphorus in the corn leaf in 1958. Raub silt loam, Purdue Agronomy Farm, Lafayette, Indiana.

TABLE 1. The time and amount of phosphate application prior to the corn crop grown in 1958 on Raub silt loam, Purdue Agronomy Farm.

Treatment Number	Year and Crop 1952[2]	1953	1954	1955	1956	1957[2]	1958	Total Applied	Soil test 1957[1]
	Oats	Hay	Corn	Soybeans	Wheat	Hay	Corn		
	lbs. P_2O_5 per acre								
1	0	0	0	0	0	0	0	0	38
2	0	0	10	0	30	0	10	50	66
3	0	0	25	0	75	0	25	125	72
4	0	0	50	0	150	0	50	250	82
5	200	0	0	0	0	220F[3]	0	420	85
6	200	0	10	0	30	180F	10	430	85
7	200	0	25	0	75	120F	25	445	100
8	600	0	0	0	0	340F	0	940	170
9	600	0	10	0	30	340F	10	990	180
10	600	0	25	0	75	340F	25	1065	200

[1] Test before 1957 fertilizer applied.

[2] Fertilizer applied broadcast, in these years all other applications applied in the row.

[3] F means fall application.

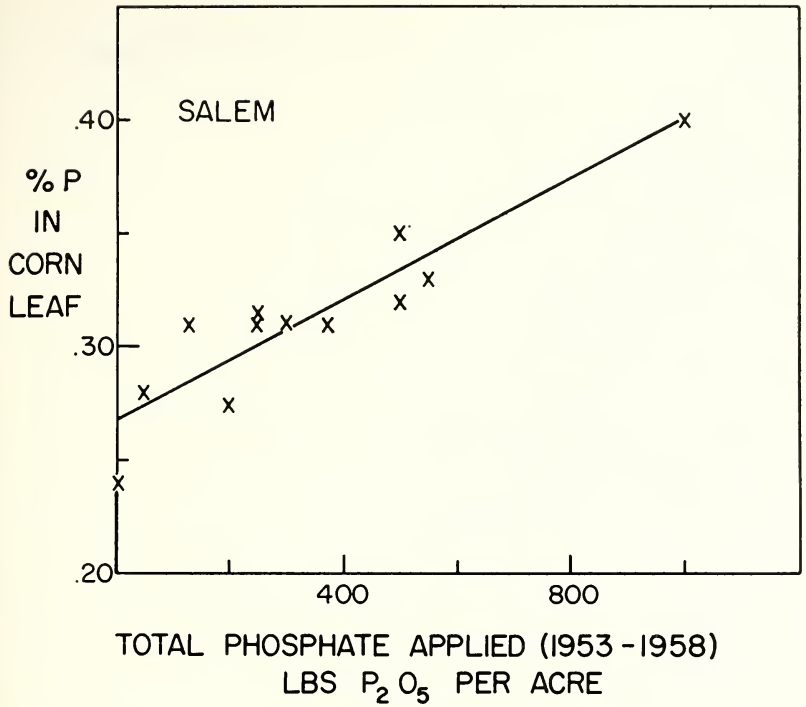

Figure 2. The relation between phosphate applied from 1953-1958 inc. and the percent phosphorus in the corn leaf in 1958. Bedford silt loam, Salem, Indiana.

TABLE 2. The time and amount of phosphate application prior to the corn crop grown in 1958 on Bedford silt loam. Salem, Indiana.

Treatment Number	Year and Crop						Total Applied	Soil test 1958
	1953	1954	1955	1956	1957	1958		
	Wheat	Hay	Corn	Wheat	Hay	Corn		
	lbs. P_2O_5 per acre							
1	0	0	0	0	0	0	0	26
2	0	0	10	30	0	10	50	15
3	0	0	25	75	0	25	125	27
4	0	0	50	150	0	50	250	55
5	250B[1]	0	0	0	0	0	250	72
6	250B	0	10	30	0	10	300	51
7	250B	0	25	75	0	25	375	75
8	250B	0	50	150	0	50	500	66
9	500B	0	0	0	0	0	500	200
10	500B	0	10	30	0	10	550	117
11	1000B	0	0	0	0	0	1000	420

[1] B refers to broadcast application, all other applications applied in the row.

Some Observations on the Effect of Vertical Mulching

Russell D. Frazier and A. R. Bertrand, Purdue University[1]

Vertical mulching is a modification of subsoiling. Research has been under way on vertical mulch at Purdue since 1955. Several popular articles have been published on vertical mulching and considerable interest has been expressed in the practice. The purpose of this paper is to summarize some of the results which have been obtained by several workers and suggest what may be expected from this practice.

To install vertical mulch channels, a subsoiler blade is modified by adding wings that hold the channel open to accommodate the mulch material. Crop residues are blown into the channel by a field chopper which is drawn by the same tractor as is the subsoiler (5). A wheel tractor of three to four plow capacity has been used to pull the entire apparatus when the chopper had its own mounted engine. The channels are generally spaced at 80 inches and are 18 to 20 inches deep.

Vertical mulching has an advantage over subsoiling because the organic matter which is introduced holds the channels open, allowing relatively free passage of moisture and air between the land surface and the subsoil.

Parr (4) found that there was much more earthworm activity adjacent to vertical mulch channels as compared with subsoil channels. Bulk density at 0 to 3 inches from the channel wall and 12 inches below the surface was 1.35 for vertical mulch 14 months after treatment. A similar figure for subsoiling was 1.41, which was significantly higher than on the vertical mulch slots.

Hypothesizing that moisture intake into a soil would be modified both as to rate and pattern under vertical mulch treatment, a pilot study on channels with a 4 percent slope and a free outlet was initiated (1). Conclusions were that where there is a more permeable layer at relatively shallow depths, the channels will discharge water quite readily into the substrata. When the subsoil is saturated, the channels will carry off large amounts of water in excess of that seeping into the subsoil.

In a study on level Fincastle silt loam, sprinkler irrigation was supplied and the pattern of movement of water studied. Moisture resistance units were buried in a grid pattern perpendicular to the vertical mulch channels. A sudden drop in resistance was taken as evidence that the moisture front had reached the location of a resistance unit. An automatic multiple recording device was used to record the readings of the resistance units. The wetting pattern of applied moisture showed that the vertical mulch channels acted to supply water to the subsoil earlier than the water could seep down from the surface of an unmulched soil.

Intake rates were calculated on mulched and unmulched plots. The average intake rates for vertical mulched plots were 1.7 inches per hour, while rates for the unmulched plots were 1.0 inches per hour. Calculations were made on the basis of the amount of infiltration which had occurred

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[1] Journal paper number 1524, Purdue University, Agricultural Experiment Station.

0.82 hours after onset of irrigation. Patterns of wetting found in the field were quite similar in shape to those found by Swartzendruber (6) using a sand model. A comparison of these patterns can be seen in figures 1 and 2.

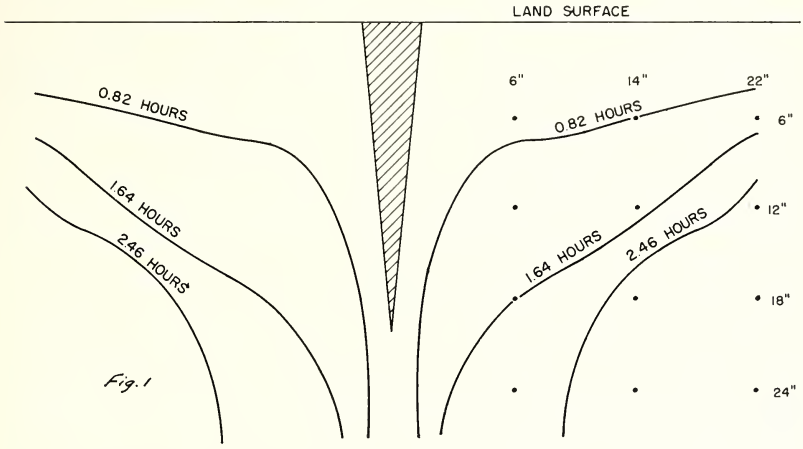

Figure 1. Location of the wetting front in Fincastle silt loam at several times after onset of irrigation (1).

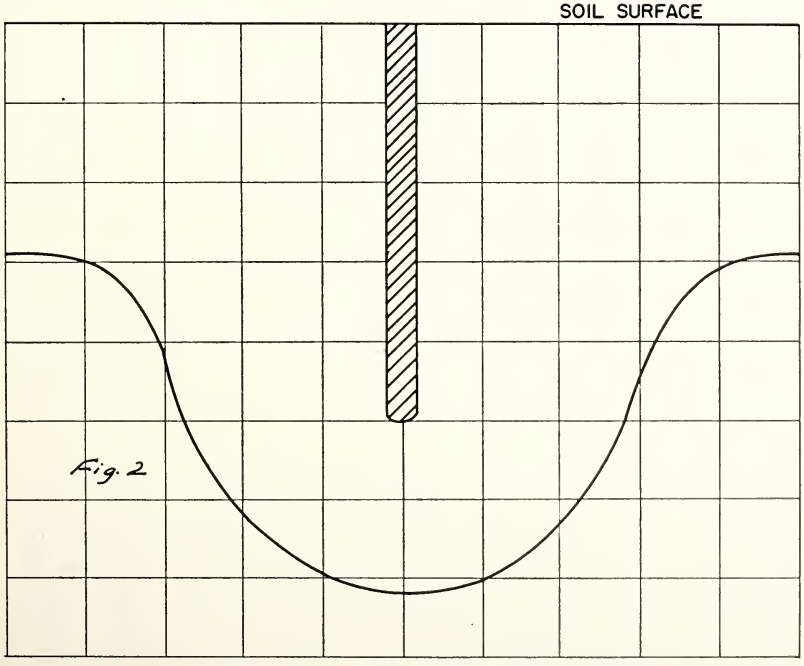

Figure 2. Location of the wetting front in a uniform sand model (6).

Runoff measurements have been made comparing vertical mulch and other treatments on small watersheds at the Purdue Throckmorton Farm. Total runoff is given in table 1 for first and second year channels for the

TABLE 1. The Effect of Tillage on Runoff

Treatment		Total Runoff in Inches		
		1957	1958	
Surface	Subsoil	1st year channel	1st year channel	2nd year channel
Plow	None	3.0	4.2	7.3
Field cultivator	None	1.6	7.4	5.3
Plow	Subsoil	0.2	4.0	5.3
Field cultivator	Subsoil	1.0	6.2	6.4
Field cultivator	Vertical mulch	0.2*	5.4**	5.2**

* Channel left open through the year.

** Channel top closed by tillage in the spring.

Data from 3 acre watersheds at Purdue Throckmorton Farm.

years 1957 and 1958. It should be noted that in 1957 the channels were left undisturbed through the growing season by tilling with a field cultivator parallel to the vertical mulch channels. The surface tillage treatment on the watersheds was changed in 1958, making no effort to avoid the vertical mulch channels. It can be seen that the channels were apparently very effective in 1957 when the channels were left open to the surface.

Vertical mulch channels were installed on the Paul Leamon farm in Tippecanoe County in 1956. The soil was a nearly level Fincastle silt loam. Corn yields on the conventionally tilled check plots in 1957 and 1958 were 105 and 97 bushels per acre respectively. Corn that was fertilized in the spring with an application of 100 + 100 + 100 yielded 112 and 103 bushels in 1957 and 1958 respectively. The vertical mulch plots yielded 120 and 119 bushels per acre in those years with the same fertilizer treatment as the spring fertilized plots.

Reports from the Agricultural Research Service, using a rainfall simulator (3) indicate that with the tops of the vertical mulch channels removed by tillage, runoff and soil loss were not reduced below that of the un-subsoiled check area. It was not felt that the rainfall simulator was a completely satisfactory device to evaluate the effectiveness of this type of subsoil treatment, due to the nature of the treatment and the size of the experimental area.

From the foregoing studies it would appear that surface tillage, which removes the tops of the vertical mulch channels, reduces the efficiency of the channels. Apparently, when vertical mulch channels are left open to the surface, they can conduct moisture into the substrata quite effectively. However, when the surface 6 to 8 inches of the channel is removed by tillage, the channels do not fill with water very readily. Under these conditions it can be theorized that the channels will not receive water from the plow layer until the wetting front is somewhat below the tops of the truncated channels. When the surface of the channel is closed, infil-

tration will be necessarily reduced with accompanying increases in runoff and erosion, with respect to the situation with the channel tops open.

Frequently cracks appear through the plow layer directly above the buried vertical mulch channels. It is difficult to predict what effect these cracks may have in allowing water to enter the channels.

To date, most work has been done with channels about 7 feet apart. This spacing is quite satisfactory where vertical mulching is done on pastureland or other noncropland. On cropland however, it is quite difficult to avoid damaging the tops of the channels. In order for vertical mulching to be effective and practical, some means must be developed to conduct farming operations without disturbing the channels. One possibility might be to use a wider channel spacing and limit farming operations to the inter-channel areas. Channel depth would probably have to be increased to maintain effectiveness if spacing were increased.

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Genesis of Limestone Profiles in the Tropics

Cyril B. Brown, Purdue University

Introduction

Tobago is one of the West Indian islands in the equatorial region of the Caribbean archipelago. It is located at 11° 15′ North latitude, 60° 40′ West longitude which places it near the Southern tip of the Antillean arc, 20 miles North East of Trinidad. Its small area, climate, and geology are typical of many of the West Indian islands. The author believes that many similar soils exist throughout the West Indies and hopes that this study may be of some assistance to soil scientists in the Caribbean. It has an area of 116 square miles, average annual rainfall is 79 inches in the section studied. Maxwell (4) describes its geology as volcanic, igneous and coraliferous.

The present paper is a study of shallow and deep profiles found on coral in Tobago. The author has received much assistance from G. C. Witt, the Soil Chemist of Tobago, and his staff, and Professor Joe L. White of Purdue University. The author is particularly grateful to the National Science Foundation for the use of the X-ray diffractometer at Purdue University.

Morphological Descriptions

These soils have never been mapped. They have been given names, by convention, of the locations where they were first described, and legends according to the Soil Survey Manual of the U. S. D. A. (5). Thus symbol C_1 would represent the first soil described on coral in the mapping unit, and the missing C_2 is a peat which has been omitted in this paper.

Mechanically Decomposed Coral

Pigeon Point Sand

$$\frac{5 \cos C_1}{\text{A:1}} = \frac{\text{deep, coarse sand on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Greyish brown coarse sand
5–60″ —Greyish brown coarse sand, no horizon differentiation.

Shallow Soils on Coral

Crown Point Clay

$$\frac{2cC_3}{\text{A:1}} = \frac{\text{Shallow clay on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Friable brownish red clay.
5–6″ —Friable brownish red clay.
6″ —Coral: large masses of coral come to the surface, and brownish red soil is found in cylindrical pipes and fissures in the limestone.

Milford Clay (shallow).

$$\frac{2cC_4}{\text{A:1}} = \frac{\text{Shallow clay on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Friable dark olive brown clay.
5–6″ —Moderate yellowish brown and olive clay.
6″ —Coral: large masses of coral come to the surface and olive brown soil is found in cylindrical pipes and fissures in the limestone.

Deep Soils in Coral

Shirvan Clay Loam

$$\frac{\text{5 sclc } C_5}{\text{A:1}} = \frac{\text{deep, sandy clay loam on clay on coral}}{\text{0 — 3\% slope : no erosion hazard}}$$

0–2″ —Brown clay loam.
2–14″ —Yellowish brown speckled gray clay.
14–28″—Yellow olive finely mottled reddish brown and speckled yellowish brown clay.
27–53″—Moderate olive clay with large red mottlings.
53″—Yellow brown speckled black silty clay loam with white calcareous concretions.

Friendship Sandy Clay Loam

$$\frac{\text{5 fscl } C_6}{\text{A:1}} = \frac{\text{deep, fine sandy clay loam on coral}}{\text{0 — 3\% slope : no erosion hazard}}$$

0–6″ —Olive black sandy clay loam.
6–12″ —Olive brown sandy clay loam with small black spherical concretions.
12–30″—Yellow brown clay loam with small black spherical concretions.
30–48″—Olive gray and yellow brown clay loam with small black spherical concretions.

Hydromorphic Soil on Coral

Buccoo Clay

$$\frac{5cC_4}{\text{A:1}} = \frac{\text{deep clay on coral}}{\text{0 — 3\% slope; no erosion hazard}}$$

0–6″ —Friable olive gray and brownish gray clay.
6–18″ —Pale olive and yellowish brown clay.
18–30″—Yellowish brown and pale olive clay with small black spherical concretions.
30–36″—Medium gray, yellow brown, mottled brown clay.
36–50″—Olive gray, bluish gray clay with yellow brown and reddish streaks.

Pigeon Point Sand occurs along the island foreshore—it is a coral beach sand with a fluctuating water table changing with tide, but the soil surface is normally above the high water mark. Immediately landwards of Pigeon Point Sand is Crown Point Clay, then comes the Shallow Milford Clay. This increases in depth reaching a maximum solum of 50 inches as one gets further inland, then changes almost suddenly into Shirvan Clay Loam near the volcanic foothills to the North and East. There is only one site of Friendship Sandy Loam and it is located in an area, where geomorphologically it represents a raised beach. Buccoo is the

depressional soil developed under hydromorphic conditions and is found near the foreshore. It is totally inundated for long periods during the rainy season.

Analytical Methods

All the methods used have been described by Chenery[1] except that for X-ray analysis. $<2\mu$ clay fraction was separated by centrifugation as outlined by Jackson[4]. Clay samples were oriented on glass slides solvated with glycol and patterns were obtained from a General Electric XRD-5D1 X-ray diffractometer using CuKα radiation.

Physical, Chemical and X-ray Diffraction Data.

Depth Inches	pH	Sand %	Silt %	Clay %	K_2O p.p.m.	17.7Å Relative Intensities*	7.25Å Relative Intensities*	3.04Å Relative Intensities*	Nature of 7.2Å peak
Pigeon Point Sand									
0-6	8.6	89	6	6	85	——	——	0.5	——
6-36	8.8	90	4	6	80	——	——	0.5	——
36-48	9.0	88	5	7	85	0.5	——	0.5	——
Crown Point Clay									
0-5	8.2	26	7	65	239	——	2.5	——	Sharp
5-6	8.4	14	9	75	407	——	2.0	——	Sharp
Coral	8.3	79	14	3	129	——	0.8	2.2	——
Milford Clay									
0-5	7.6	26	16	53	407	——	4.2	——	Sharp
5-6	8.1	20	7	72	369	——	2.5	——	Sharp
Coral	8.5	92	1	5	118	——	0.8	2.2	——
Shirvan Clay Loam									
0-2	6.3	34	21	39	117	0.8	1.9	——	Sharp
2-14	4.8	24	7	68	201	1.0	1.4	——	Broad
14-27	4.3	18	9	70	137	1.5	1.8	——	Broad
27-53	4.3	19	13	65	148	3.2	6.0	——	Sharp
53	8.3	21	32	38	64	12.8	3.6	——	Broad
Friendship Sandy Clay Loam									
0-6	7.4	59	6	30	171	1.0	5.0	——	Sharp
6-12	8.0	62	8	26	85	1.0	3.1	——	Broad
12-30	9.1	46	9	44	106	8.8	7.5	——	Sharp
30-48	8.9	47	8	43	80	8.4	7.0	——	Sharp
Buccoo Clay									
0-18	7.4	21	19	52	105	14.8	2.6	——	Broad
18-30	6.5	18	17	63	221	16.0	3.0	——	Broad
30-50	7.2	19	21	55	236	13.6	2.5	——	Broad

* Peak height in inches.

Discussion

The results fit the following postulate.

1. The shallow soils have been formed from volcanic ash deposited on coral. Hardy (2) has stated that on 16th Oct. 1902 nearly 4 tons of volcanic ash per acre, and on 22nd March 1903 nearly 3½ tons of volcanic ash per acre fell on nearby Barbados from eruptions in St. Vincent and Martinique.

2. The deep soils have received, from the nearby hills, volcanic detritus on which volcanic ash was later deposited. These deeper profiles represent soils developed from two different types of volcanic material. The analytical data support this view e.g. the marked difference at 53″ in the Shirvan, and 30 inches in the Friendship soils. This also explains the similarities between the physical and chemical data of the top and bottom horizons of the Shirvan since detritus is still being deposited on the surface.

3. The end product of weathering is kaolinite except in the hydromorphic soil where montmorillonite predominates. All the surface horizons of the well drained soils have sharp well defined 7.25Å peaks, so that the appearance of similar peaks within the profile suggests a previous A horizon. Such peaks occur at 27-53″ in the Shirvan, 12-30″, in the Friendship. Also in support of the postulate is the absence of a 3-04Å peak in any of the sola studied.

Conclusion

None of the soils found on coral are genetically related to the underlying coral. The shallow soils are entirely of volcanic ash origin. The deeper ones have been influenced by volcanic ash and volcanic detritus.

Detritus is even now being deposited on the surface of the deeper soils. The end product of weathering is kaolinite while montmorillonite accumulates in the poorly drained soils. There is present in some horizons a mineral with maximum spread of spacing 7.13Å to 7.62Å which suggests a low hydration variety of halloysite. This mineral is associated with poor internal drainage. Similar conditions should exist throughout the West Indies where the red soils on coral may not be Terra Rossas, nor the dark ones Rendzinas although there are great similarities. An interesting side observation from the study is that the coconut palm will not tolerate high concentrations of montmorillonite.

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Wetland Transformation in the Wisconsin Drift Area of Indiana[1]

BENJAMIN F. RICHASON, JR., Carroll College

Land drainage in the past century has played an important part in the development of Indiana agriculture, as well as in the improvement of public health. Although complete drainage statistics have not been compiled, at least 2.4 million acres added to the cultivated land area of the state and approximately an equal amount made more productive and profitable doubtless is a conservative estimate of the benefit of drainage to agriculture in Indiana.[2] The benefits to health would be exceedingly difficult to measure, but it is known from early records that malaria was generally endemic, and occasionally hyperendemic, in those areas of the state where drainage is now most complete, and that this dreaded disease has largely disappeared from those areas today.

Although land drainage in Indiana dates back to 1799 (1), few records were kept of the length of drainage installations, much less of the amount of land actually drained. The first census of drainage was taken in 1920, at which time statistics on farmland actually supplied with drainage were included. The reporting of farmland drained was continued in the 1930 census, but not subsequently. Both the 1940 and 1950 census of drainage present figures for land in drainage enterprises only; a classification that fails to include some land drained by virtue of its location outside of drainage enterprises, as well as including land not supplied with drainage within drainage enterprises because of the "common enemy" rule under which Indiana drainage operations are carried out.

In an effort to determine the location of those areas in Indiana where drainage need was, and is potentially, greatest, an attempt was made to locate the former wetlands of the state. The hydromorphic sequence of I-, VII-, VIII-, IX-, and X-profile soils have been used to locate these areas, as those soil relationships which existed under natural equilibrium persist in spite of the disturbed natural balance due to occupance (2). By using the drainage profile as a means of assessing the natural drainage adequacy of soils, it may be seen (Fig. 1) that wetlands, and their subsequent drainage, are phenomena of the northern two-thirds of Indiana, particularly within the area of Wisconsin Drift.

From Figure 1, based on the soil surveys and Bushnell's soil associations (3), it is observed that wetlands are most extensively developed in the northwestern, prairie section of the state where lacustrine plains predominate. With the exception of the northwest, the mode of wetness by county units in the area of Wisconsin Drift appears to be between 25-50

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[1] This paper is based on a part of the research carried out with the aid of a Science Faculty Fellowship granted to the author by the National Science Foundation, 1958-59.

[2] In regard to wet lands, these figures are at best estimates, but are based on census statistics. The 1930 Census of Drainage reported 2,430,789 acres in drainage enterprises as unfit for cultivation, and 2,365,603 acres suitable for only a partial crop prior to drainage.

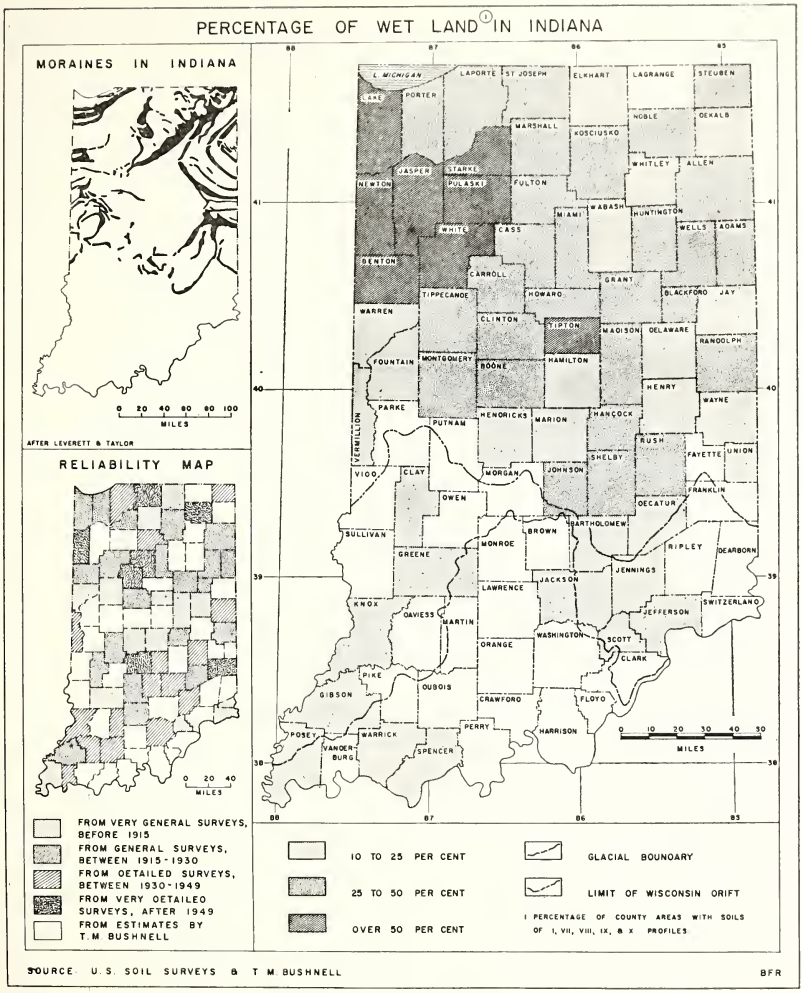

Figure 1

per cent. South of the Shelbyville and Bloomington morainic systems, those counties showing up as having between 10-25 per cent of their areas occupied by wet soils are located primarily within the area of older drift of Illinoian Age. The driftless area of the state, on the other hand, appears to be sigfinificantly drier in terms of the natural drainage adequacy of its soils.

The wetlands of Indiana appear to be intimately associated with topography (Fig. 2). Physiographically, northern Indiana may be divided generally into areas of till plains, morainic belts, lacustrine plains, and glaciofluvial terraces and bottoms (4). Throughout much of the area natural drainage is too youthful to have provided outlets for numerous,

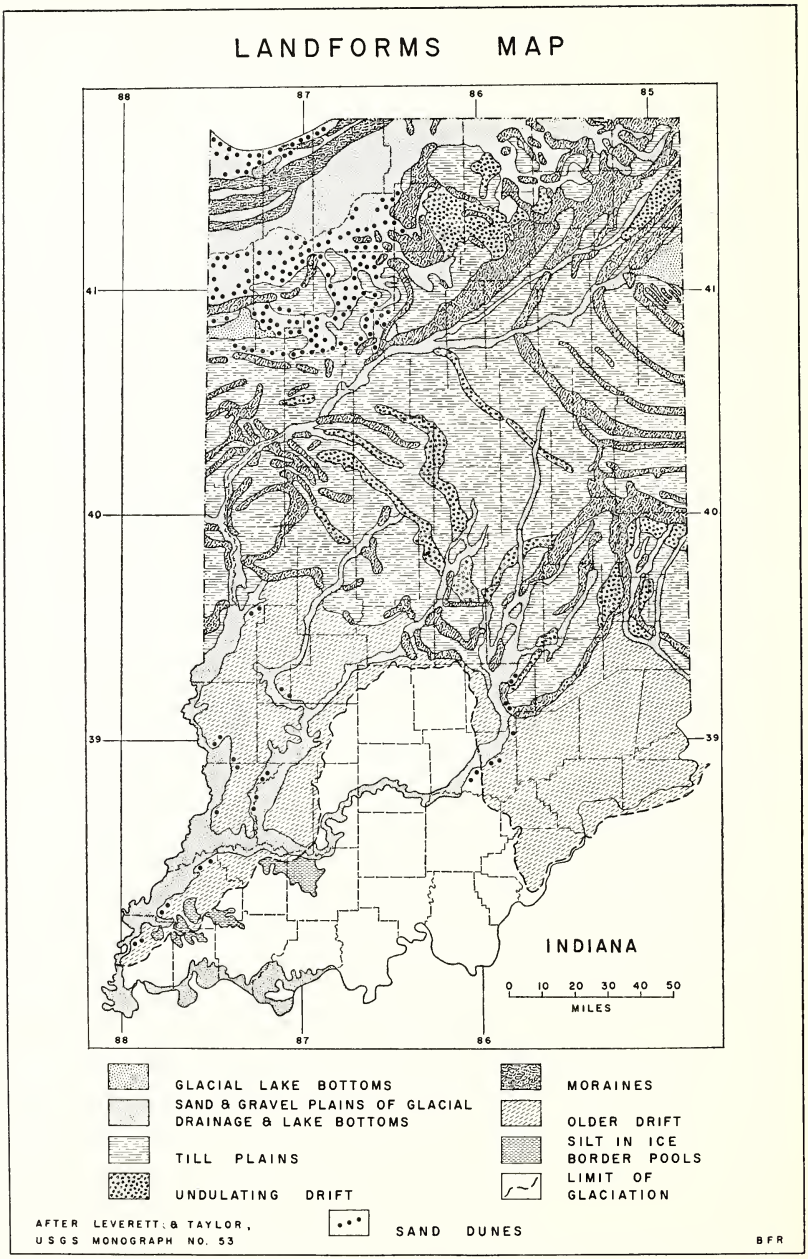
LANDFORMS MAP
88
87
86
85
41
40
39
INDIANA
0 10 20 30 40 50
MILES
GLACIAL LAKE BOTTOMS
SAND & GRAVEL PLAINS OF GLACIAL DRAINAGE & LAKE BOTTOMS
TILL PLAINS
UNDULATING DRIFT
MORAINES
OLDER DRIFT
SILT IN ICE BORDER POOLS
LIMIT OF GLACIATION
SAND DUNES
AFTER LEVERETT & TAYLOR, USGS MONOGRAPH NO. 53
BFR

Figure 2

enclosed upland depressions, or to have sufficiently lowered the local and regional water tables so that subsoil saturation is eliminated.

Figure 3 attempts to locate as precisely as possible, within the limits of accuracy of the available soil surveys which served as the source, the wetlands of the Wisconsin Drift area of Indiana. The phenomena of poorly drained and very poorly drained soils may be correlated with the map of landforms (Fig. 1). The dry sections within the area of Wisconsin Drift correspond to the gravelly moraines, porous terraces, and outwash bottoms.

The areal pattern of wet soils within the till plain sections betrays their origin. Figure 3 shows that the soils with wet profiles occupy positions resembling the braided patterns of silt-choked streams. The long attenuated and deranged patterns connect with other wet areas in an irregular and discontinuous fashion; being particularly representative of the patterns of Brookston soils.

The wetland pattern of the morainal-lake section of the northeast stands in contrast to that of the till plains. Here the wet soils, by and large, occur as separate entities, surrounded by the drier soils of the rises and knobs of the moraines. So numerous do these undrained depressions of swamps, marshes, and lakes become that morainal patterns, such as in the areas of the Packerton, Maxinkuckee, and Valparaiso moraines, are almost obliterated.

The pattern of wetlands in the lacustrine plains of the northwest is somewhat transitional between that of the central till plain on the south and the morainal section to the east. Isolated pockets of very poorly drained soils alternate with excessively drained uplands, while threading through the area are better-drained glacial torrent channels interspersed with extensive wet glaciolacustrine plains. Thus, the wetland environment of the Wisconsin Drift area of Indiana may be resolved into those areas with a perched water table which characterizes the till plains, naturally undrained depressions within moraines, and porous sand plains of lacustrine origin characterized by a perennially high regional water table.

A comparison of Figures 3 and 4 shows patterns of similarity. In 1920, the census reported 8.3 million acres of farmland provided with artificial drainage, while the comparable figure reported by the 1930 census was 6.8 million acres; the decrease apparently being explained by more careful enumeration in the latter census report (5). The heart of the area actually provided with drainage in 1930 was located in the central section of the flat lands of the till plain, the most prosperous agricultural area in the state.

By correlating the distribution of phenomena illustrated by the preceding maps with that of land in drainage enterprises in 1950 (Fig. 5), it may be seen that, for the most part, land in drainage enterprises is located in those areas of most extensive wetness, principally within the area of Wisconsin Drift, and that the major areas of land drainage in Indiana correspond to the location of drainage enterprises. The correlation of these phenomena is accentuated by the fact that the areas of less intense wetland distribution and drainage enterprise distribution corresponds, generally, to the better drained areas of the moraines, undulating drift, outwash terraces, and alluvial bottoms of the state. On the other

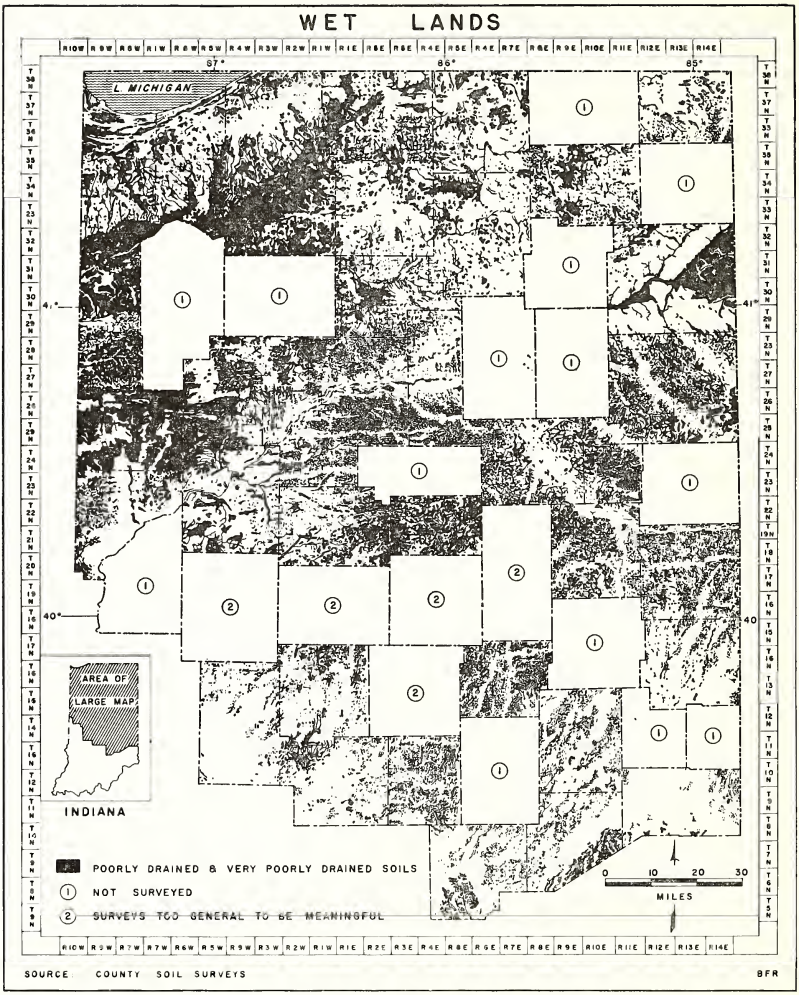

Figure 3

hand, attention is directed to the fact that the areas of most intense land drainage and largest areas of land in drainage enterprises are located within the flat, clay lands of the central till plain. Areas of major drainage enterprise development in the northwestern, northeastern, and southwestern portions of the state alludes to locally acute drainage problems as the map of lands actually provided with drainage (Fig. 4) shows relatively smaller areas of land drained in these sections. A county by county comparison of such quantitative phenomena shows that those counties having the largest areas of farmland drained also have the largest areas in drainage enterprises, because, in most instances, organization for the construc-

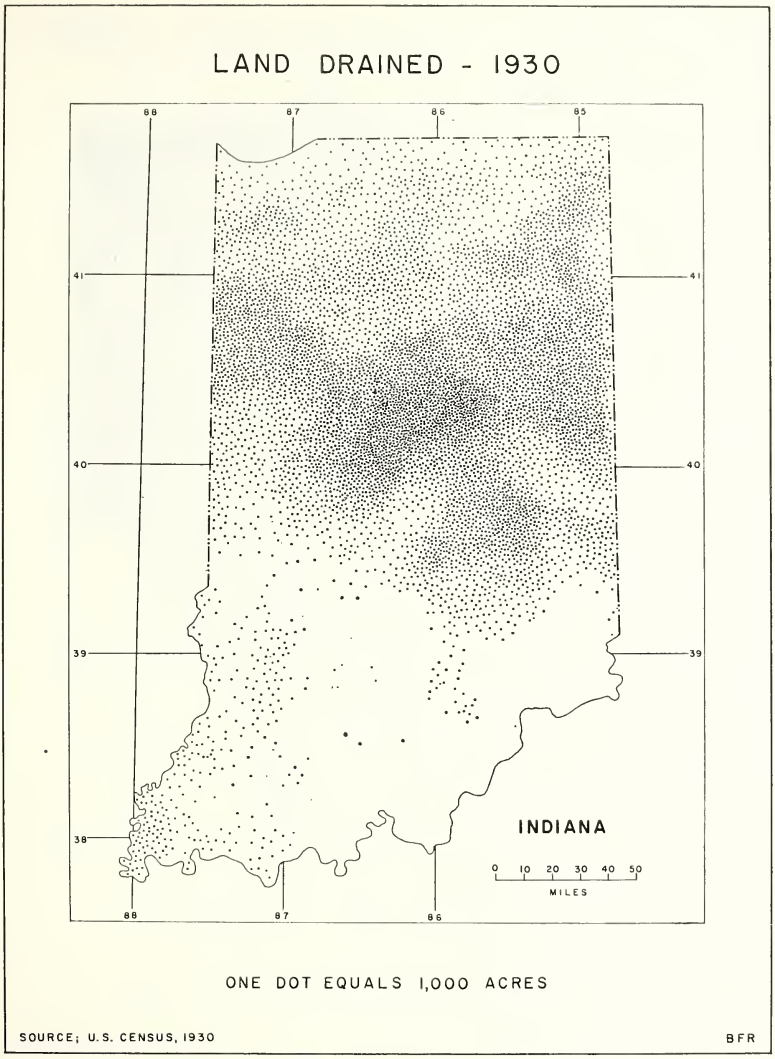

Figure 4

tion and maintenance of outlet drains is necessary to the installation of farm drains.

Following a pattern developed by Leslie Hewes (6), the cartogram of Drainage Condition Prior to Drainage Enterprises (Fig. 6) has been prepared in an effort to further aid in the interpretation of where drainage need was the greatest within the area of Wisconsin Drift, the area already established as being the most extensively and intensively wet area in Indiana. Using the statistics in the 1930 census, the areas of land in

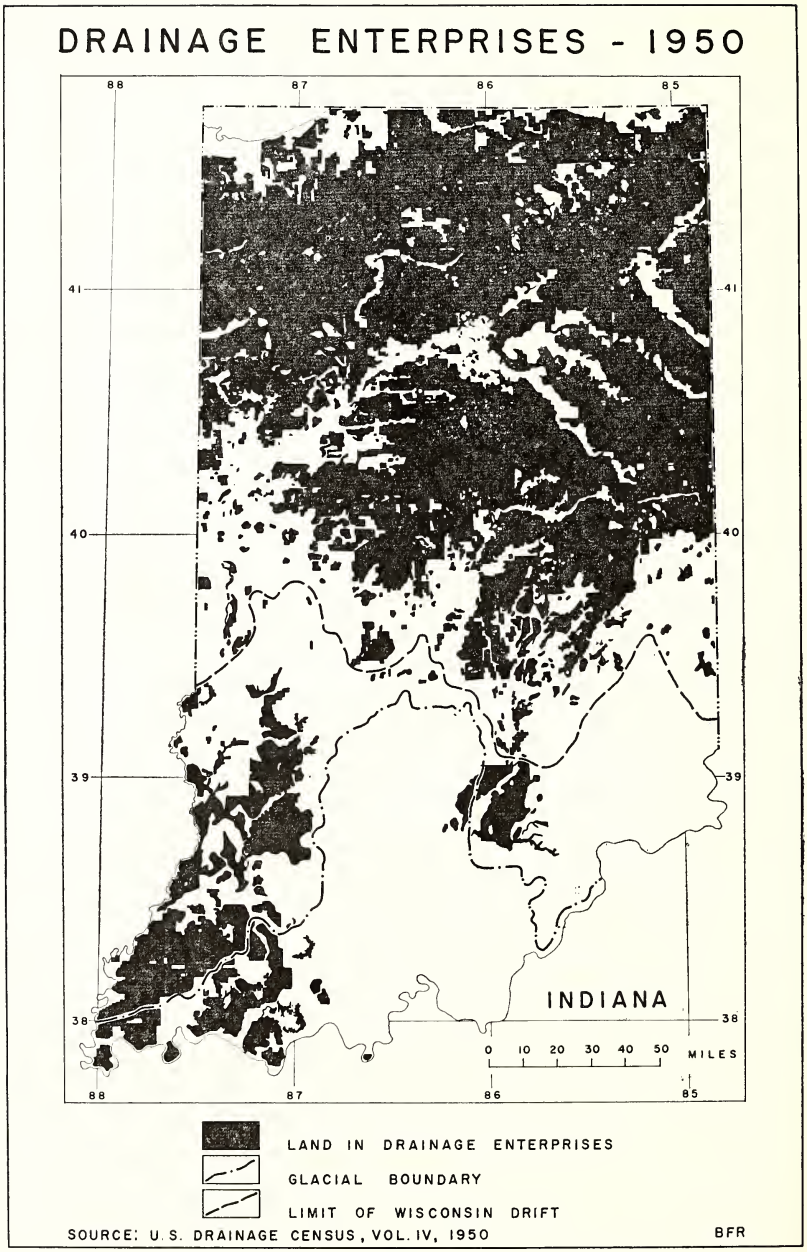
DRAINAGE ENTERPRISES - 1950
88
87
86
85
41
40
39
38
INDIANA
0 10 20 30 40 50 MILES
LAND IN DRAINAGE ENTERPRISES
GLACIAL BOUNDARY
LIMIT OF WISCONSIN DRIFT
SOURCE: U.S. DRAINAGE CENSUS, VOL. IV, 1950
BFR

Figure 5

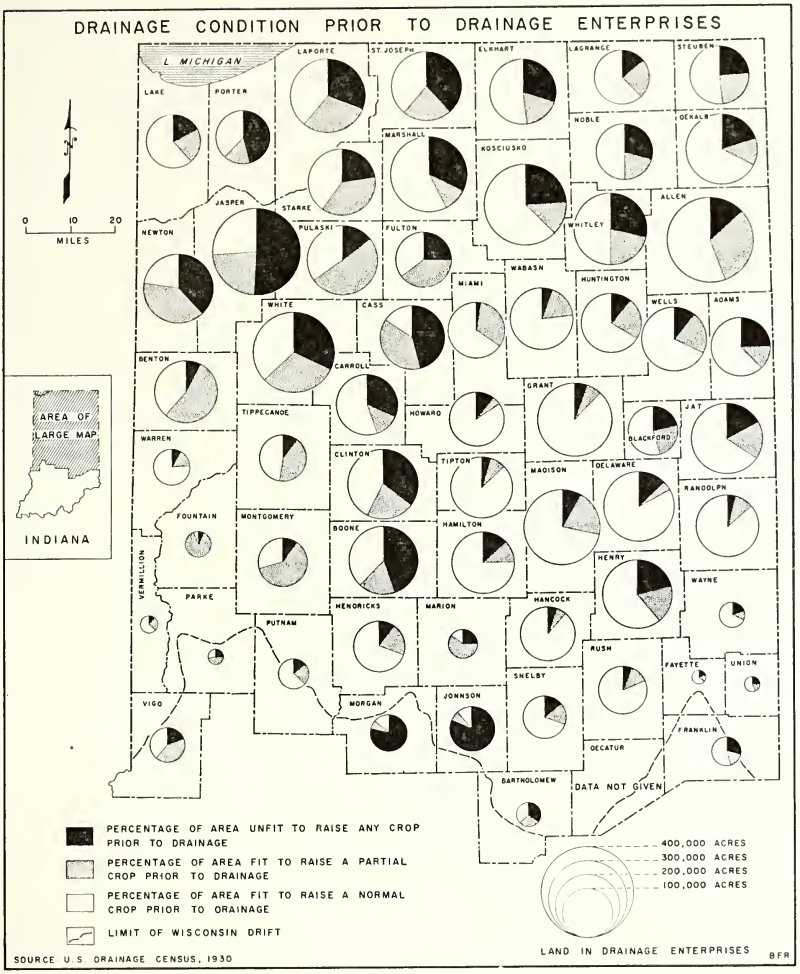

Figure 6

drainage enterprises that were unfit for any crop, suitable to raise only a partial crop, and fit to raise a normal crop prior to the establishment of drainage enterprises were plotted. Where a large percentage of a county was incorporated in drainage enterprises, these figures become meaningful. In the northwestern part of the state, with local exceptions, over one-half of the areas within drainage enterprises were not able to raise any crop, or at best only a partial crop, prior to the establishment of drainage enterprises. Again, the cartogram shows that in the counties of the morainal area, over one-third of the land in drainage enterprises was unable to raise a normal crop prior to drainage. In the central till plain it is seen that large percentages of the area were capable of producing a normal crop prior to the establishment of drainage enterprises, indicating a naturally

better drained environment than is indicated by the map of wetland distribution.

In the extreme southern section of the till plain it may be seen that large percentages of small drainage enterprise areas were unfit to raise any crop prior to drainage, indicating that drainage enterprises were established only in areas where drainage problems were acute, and that little had been done by way of private land drainage within areas incorporated in drainage enterprises before the establishment of the latter.

In an effort to determine the amount of land now drained in Indiana, sources in addition to the census reports have been consulted. Under the Agricultural Conservation Program (ACP), federal funds are available to landowners in order to help defray the expenses of inaugurating certain conservational practices. The drainage of agricultural lands by both ditches and tile are included in this program. Such drainage works are usually planned and surveyed by the Soil Conservation Service county work units and reported to the ACP for authorization of financing. Thus, the amount of land actually drained by ACP funds is a matter of record.

In Indiana, 1,107,744 acres of land were drained with the aid of ACP funds from 1936 to 1957, while 1,041,013 acres of land were drained with the aid of ACP funds between 1940 and 1957, inclusive (8). The difference between the above figures shows that 66,731 acres were actually provided with drainage by ACP funds in Indiana prior to 1940, and after ACP was organized. Thus, only 6.2 per cent of the land drained with the aid of ACP funds was drained before 1940. This still leaves a four-year period unaccounted for in terms of land drainage in Indiana, as the next authoritative report on the amount of land drained is contained in the 1930 Census. Statements by ACP officials and Soil Conservation Service personnel, coupled with the small amount of land drained by ACP funds prior to 1940, would lead to the belief that little land drainage was carried out in the decade 1930-1940. Various authorities state that little was done in their respective counties in regard to land drainage between 1930 and 1940, primarily because of the depressed agricultural conditions in that decade; being more acute prior to 1936 than afterwards. Thus, it may be safely assumed that the vast majority of land drained with the aid of ACP funds was drained after 1940, and that in all probability, little land drainage was undertaken in the economically depressed years prior to 1936 when federal funds for agricultural improvements were not available. If the 1,107,744 acres of land drained by ACP funds from 1936 to 1957, inclusive, are added to the 1930 Census figures of all farmland supplied with drainage, it is apparent that somewhere in the neighborhood of 7.9 million acres of land are being drained in Indiana.

The 1,107,744 acres of land drained with the aid of ACP funds, however, does not take account of other land drained privately, land drained by individuals who do not qualify for ACP funds, or land that is actually drained by county ditch and tile lines. The ACP estimates that the figures for land supplied with drainage for Indiana represents about 75 per cent of the land actually drained between 1936 and 1957. Assuming this figure, although highly subjective, to be approximately correct, then 1,476,990 acres of land were supplied with artificial drainage between 1936 and 1957, bringing the total amount of land provided with drainage in Indiana

to approximately 8.3 million acres. From this, and previous conclusions, it becomes apparent that the major amount of farmland drainage in Indiana was inaugurated prior to 1930.

A county by county comparison of ACP statistics on land drainage in Indiana reveals that the largest percentages of land drained in the area outside of the region of Wisconsin Drift were drained after 1940, utilizing ACP aid. Areas within the Wisconsin Drift of Indiana show smaller percentages of land drained after 1940. Evidently, where artificial outlets were early supplied by legally organized drainage enterprises, the greatest amount of land drainage was undertaken prior to 1930, while in those areas where drainage problems are not extensive, locally needed drainage was inaugurated only when the costs of such installations were at least partially subsidized by federal funds.

Probably few other land areas in the United States presented such an imposing and inhospitable picture to settlers and travelers as did the wet forests and prairies of Indiana, and probably no other natural phenomenon, excepting the forests, has been so completely eradicated. Artificial drainage has smoothed out the differences in the natural environment so that one can now travel the breadth and length of the area of Wisconsin Drift in Indiana unaware of the silent enterprises that must be continually and vigilantly maintained as a bulwark in the battle against too much water in an effort to insure high crop yields and to minimize crop failures.

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Moisture Characteristics of Some Representative Indiana Soil Types

DAN WIERSMA, Purdue University[1]

The capacity of soils to absorb and store water is of interest to agronomists, engineers, and other associated with soils. However, soils differ in their water holding characteristics, ranging from ½ inch per foot for the coarse textured soils to over 2½ inches for the fine textured soils. In the layman's terminology, soils may be classified as droughty, not so droughty, or one having a good moisture supply. This is not adequate for our modern day agriculture, especially with the knowledge and techniques now available for determining soil physical properties.

The development of the energy concept of soil moisture has been helpful in describing the condition of soil water. It has given us a quantitative evaluation for the recommendation of many agronomic practices.

This paper is a progress report, presenting data relative to the determination of the moisture characteristics of some typical Indiana soil types. To date about 50 soils have been sampled and analyzed. Three representative soils are described and a more detailed report will be published in the near future.

During the initial phases of the project, soils which were low in moisture holding capacity were selected. These were considered as most probable for irrigation. More recently, other soils have been included, particularly those which encompass a significant area in Indiana. Samples were taken in a depth profile to secure the information from all the horizons. Several soils have been sampled at more than one location. It is always difficult to select sites which truly represent the soil type desired.

Characterizing soil water involves two major factors. The first of these is moisture content and is a capacity factor. Moisture content is usually expressed in per cent by weight based on oven dry soil. The second is an intensity factor and concerns the energy with which the moisture is held by the soil. It can be defined as the work per unit mass of water required to remove moisture from the soil. Since in the c.g.s. system, the density of water is unity, the work term is equal to pressure. This energy term is denoted as tension or suction in centimeters of water, centimeters of mercury, atmospheres, or as bars. Relating the capacity factor of a soil to the intensity factor is the moisture characteristic. Each soil has its own peculiar characteristic.

Two points which are of particular interest on the soil moisture characteristic curve are Field Capacity and Permanent Wilting Percentage. Although these are not exact points, they are extremely useful from a practical point of view. Field Capacity has been defined as the moisture content of the soil when after application of water internal drainage has essentially ceased, and the Permanent Wilting Percentage as the soil moisture content when plants fail to regain leaf turgidity when in a

[1] Contribution from Purdue University, Agricultural Experiment Station. Journal Paper No. 1529.

saturated atmosphere. The soil water between Field Capacity and Permanent Wilting Percentage is available to the plant and is a capacity term rother than an intensity. In other words, this available water is not necessarily equally available to the plant.

The one-third atmosphere percentage has been an accepted estimate of Field Capacity. This estimate is not accurate for all soil textures, one-tenth atmosphere suction is more nearly correct for the sandy soils and one-half atmosphere suction for the clay type. The fifteen atmosphere percentage has been found to correlate quite well with the wilting percentage and is most frequently used as the estimate for this constant.

A bulk density sample was necessary for each soil horizon for the conversion of soil moisture content from a per cent by weight to a per cent by volume. A modified Lutz sampler was used for obtaining this measure. After securing the per cent by volume, a simple multiplication of this value by the depth of soil gives the depth of water. This is shown in the equation:

$$d_w = \frac{B_d}{W} \times \frac{P_w}{100} \times D_s$$

Where d_w = depth of water
B_d = bulk density of the soil
W = density of water
P_w = per cent moisture on a dry weight basis
D_s = depth of soil

The Lutz type sampler was also used for taking the undisturbed soil cores for the lower range of desorption suctions. The 50, 100, 200, and 345 centimeters (one-third atmosphere) of water suctions were measured on a pressure plate apparatus. The 1, 5, 10, and 15 atmosphere percentage values were determined with disturbed samples on the pressure membrane appartus.

Data for three soils, namely, Fincastle silt loam, Warsaw silt loam, Coloma loamy sand are given in Tables 1, 2, and 3 respectively. The desorption information is shown in Tables 1a, 2a, and 3a for each horizon. This data along with the bulk density gives rise to the soil moisture characteristics presented for the respective soils in Tables 1b, 2b, and 3b. The inches of water per inch of soil at the two moisture constants is given, in addition to the total depth of water in each horizon. The left hand column is an estimate of the available water in the horizon.

A practical application for this information is illustrated with the Fincastle silt loam in Figure 1. The plants can only utilize the available soil water from those horizons into which its roots penetrate. The number of inches in the upper right hand corner of each section indicates the amount of water available to the plant with the root characteristics shown.

Soil moisture characteristic data can be used for several purposes. By relating this information to the capillary rise equation, pore size distribution can be determined. With moisture characteristics of experimental soils, research workers can more accurately evaluate the moisture variable. Agricultural extension workers, Soil Conservation Service personnel, Farm Home Administration supervisors and land appraisers can make a sounder recommendation to their cooperators and clients with a

Table 1a. Fincastle silt loam

SOIL MOISTURE DESORPTION DATA

Horizon	Depth (inches)	Bulk Density (gm/cc)	Percent Water at Respective Tensions							
			50 Cm. of H_2O	100 Cm. of H_2O	200 Cm. of H_2O	1/3 Atm.	1 Atm.	5 Atm.	10 Atm.	15 Atm.
A_p	0–6	1.25	30.1	28.8	27.3	26.2	20.5	10.0	7.8	7.1
A_2	6–11	1.43	25.7	24.8	24.0	23.5	20.3	11.6	8.8	7.7
B_1	11–17	1.42	26.3	25.9	25.2	24.9	22.1	15.8	13.8	12.3
B_{21}	17–24	1.41	28.3	28.1	27.2	26.8	22.9	16.5	14.2	13.4
B_{22}	24–29	1.50	25.4	25.6	24.5	24.1	20.8	15.1	14.1	12.8
B_{23}	29–36	1.55	23.1	22.9	21.8	21.8	19.6	14.4	13.1	12.2
B_{24}	36–43	1.53	21.3	20.7	19.9	19.6	17.8	13.4	11.7	11.1
C	43–60	1.80	14.9	14.5	14.0	13.8	13.6	10.2	7.7	7.5

Table 2a. Warsaw silt loam

SOIL MOISTURE DESORPTION DATA

Horizon	Depth (inches)	Bulk Density (gm/cc)	Percent Water at Respective Tensions							
			50 Cm. of H_2O	100 Cm. of H_2O	200 Cm of.H_2O	1/3 Atm.	1 Atm.	5 Atm.	10 Atm.	15 Atm.
A_{11}	0.0–2.5	1.06	35.8	33.6	31.8	29.7	24.3	16.4	12.9	12.6
A_{12}	2.5–12.5	1.16	30.8	28.9	27.4	25.5	22.5	15.5	13.8	12.8
B_1	12.5–16.0	1.28	27.6	26.4	25.3	23.6	22.1	15.5	13.6	12.0
B_{21}	16.0–20.0	1.35	26.6	25.6	24.8	23.4	22.9	16.5	14.8	14.7
B_{22}	20.0–35.0	1.47	23.0	21.5	20.9	19.8	19.0	17.1	16.6	16.2
D	35.0–48.0	1.50	16.8	15.7	14.8	13.5	12.9	11.5	9.4	8.5
D	48.0–60.0	1.62	7.4	6.8	6.1	4.3	3.8	2.7	2.3	2.0

Table 1b. Soil Moisture Characteristics

Fincastle silt loam.

Horizon	Depth (inches)	Inch Water/Inch Soil 1/3 Atm.	15 Atm.	Total Inches Water in Horizon 1/3 Atm.	15 Atm.	Inches Available Water in Horizon
A_p	0–6	0.33	0.09	1.97	0.53	1.44
A_2	6–11	0.34	0.11	1.68	0.55	1.13
B_1	11–17	0.35	0.18	2.12	1.05	1.07
B_{21}	17–24	0.38	0.19	2.65	1.32	1.33
B_{22}	24–29	0.36	0.19	1.81	0.96	0.85
B_{23}	29–36	0.34	0.19	2.37	1.32	1.05
B_{24}	36–43	0.30	0.17	2.10	1.19	0.91
C	43–60	0.25	0.14	4.22	2.30	1.92
					Total	9.70

Table 2b. Soil Moisture Characteristics

Warsaw silt loam.

Horizon	Depth (Inches)	Inch Water/Inch Soil 1/3 Atm.	15 Atm.	Total Inches Water in Horizon 1/3 Atm.	15 Atm.	Inches Available Water in Horizon
A_{11}	0.0–2.5	0.32	0.13	0.79	0.32	0.47
A_{12}	2.5–12.5	0.30	0.13	2.96	1.31	1.65
B_1	12.5–16.0	0.30	0.15	1.06	0.54	0.52
B_{21}	16.0–20.0	0.32	0.20	1.26	0.79	0.47
B_{22}	20.0–35.0	0.29	0.24	4.37	3.57	0.80
D	35.0–48.0	0.20	0.13	2.64	1.66	0.98
D	48.0–60.0	0.07	0.03	0.84	0.38	0.46
					Total	5.35

Table 3a. Coloma loamy sand

SOIL MOISTURE DESORPTION DATA

Depth* (Inches)	Percent Water at Respective Tensions: 100 Cms. of H_2O	1/3 Atm.	1/2 Atm.	6/10 Atm.	8/10 Atm.	15 Atm.
0–6	5.6	5.6	5.3	4.8	4.6	2.5
6–12	5.1	5.1	4.9	4.3	4.4	2.3
12–18	4.3	4.3	4.0	3.6	3.4	1.8
18–24	3.9	3.9	3.2	3.2	2.9	1.6
24–36	3.2	3.1	3.0	2.7	2.5	1.6
36–48	3.6	3.5	3.1	3.0	3.0	1.8
48–60	4.9	4.9	4.2	3.9	3.4	2.3

* Bulk density for all depths 1.50 gm/cc.

Table 3b. Soil Moisture Characteristics

Coloma loamy sand

Depth (Inches)	Inch Water/Inch Soil F.C.*	15 Atm.	Total Inches Water in Horizon F.C.*	15 Atm.	Inches Available Water in Horizon
0-6	0.12	0.04	0.70	0.22	0.48
6-12	0.12	0.04	0.69	0.21	0.48
12-18	0.11	0.03	0.64	0.16	0.48
18-24	0.10	0.02	0.61	0.14	0.47
24 36	0.10	0.02	1.14	0.28	0.86
36-48	0.11	0.03	1.26	0.33	0.93
48.60	0.14	0.04	1.50	0.42	1.08

* Field Capacity as determined by soil sampling.

knowledge of these soil properties. Better design of irrigation systems, and more efficient water management by the irrigation operator is possible if there is a basis for making sound decisions.

The moisture characteristic is a unique physical property of the soil, and should be included in its description.

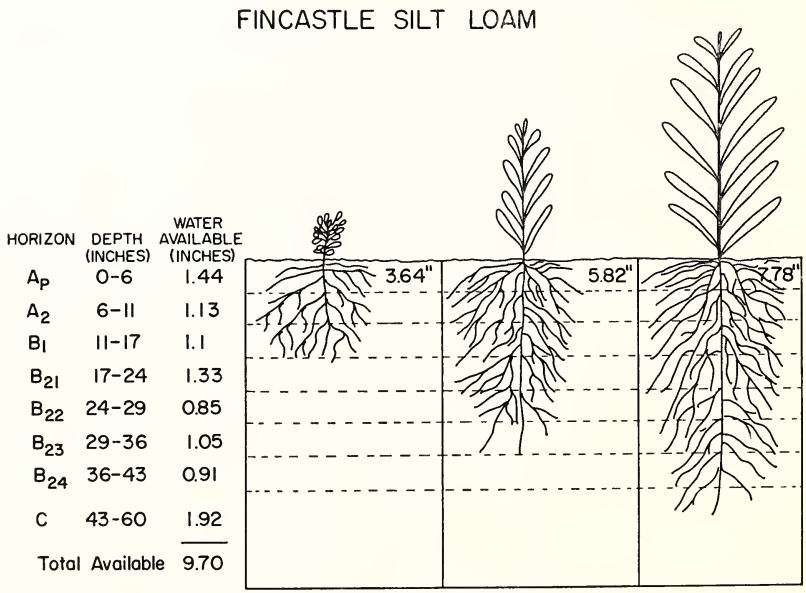

Figure 1

X-ray Diffraction Study of Indiana Limestones[1]

Brian Snow,[2] J. L. White and G. W. Bailey, Purdue University

The magnesium content of limestone is of considerable interest from an agricultural standpoint. The magnesium and calcium carbonate contents of samples of Indiana limestones from over 80 quarries have been determined (7).

The objective of this study was the determination of the relationships between the d-spacings and x-ray diffraction intensities of the characteristic peaks of dolomite and calcite and the composition of Indiana limestones.

Introduction

Limestones are composed primarily of calcite ($CaCO_3$) and/or dolomite ($CaMg(CO_3)_2$). Calcite consists of alternating layers of Ca^{++} and CO_3^{--} ions (1). In dolomite the Ca^{++} and Mg^{++} ions are present in a 1:1 ratio. Cation planes populated entirely by Ca^{++} alternate with those populated entirely by Mg^{++}; the CO_3^{--} ions lie between these planes.

Ca^{++} has an ionic radius of 1.06 A., while Mg^{++} has a radius of 0.78 A. This sizable difference is reflected in the ordered nature of dolomite and by the fact that only very limited solid solution exists between $CaCO_3$ and $MgCO_3$ except at high temperatures (5).

Goldsmith, Graf and Joensuu (2) and Goldsmith and Graf (4) have studied the relationship between the composition of calcite and dolomite and lattice constants and d-spacings. Their work indicates that calcite formed under equilibrium conditions near earth-surface temperatures would be quite low in magnesium. From the earlier work (2) it was concluded that the Ca:Mg ratio of dolomite did not deviate significantly from unity. More recently, however, Goldsmith and Graf (3) have described the occurrence of dolomite fractions that deviate compositionally and structurally from the ideal compound. These were found in Cretaceous and younger rocks and usually have excess $CaCO_3$ in their structure; some fractions contain approximately 55 mole percent $CaCO_3$.

Experimental

Limestone samples having a wide range of $MgCO_3$ contents were obtained from Dr. Roy D. Bronson of the Purdue Soil Testing Laboratory. These samples had been analyzed chemically for calcium and magnesium carbonates.

The limestone samples were ground for one hour in an automatic grinder having a mullite mortar and pestle. Slurries of the limestones were prepared with a mixture of amyl acetate and collodion (6) and allowed to dry on glass slides. Careful examination of diffractometer tracings revealed no trace of aragonite; it was therefore assumed that

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[1] Journal Paper No. 1517, Purdue University Agricultural Experiment Station, Lafayette, Indiana. Contribution from the Department of Agronomy.

[2] Participant in NSF Program for Superior High School Students, Purdue University, Summer, 1959.

the grinding treatment did not affect the d-spacings of the calcite or dolomite.

X-ray diffractometer tracings of the d_{211} spacings of the samples were made on a General Electric XRD5 diffractometer using Cu radiation. A standard quartz (Novaculite) slide was used to prepare a graph of 2θ versus errors in d-values. This graph was then used to correct observed carbonate d-values.

Diffraction angles were obtained from charts recorded at a rate of 0.2°/min. with a time constant of 2.0 seconds. Intensities were measured as height in millimeters above background.

The mole percent $MgCO_3$ in the dolomite was estimated from the relationship between d_{211} and composition as given by Goldsmith and Graf (4).

Results and Discussion

The chemical composition and x-ray diffraction data are given in Table 1. The samples are arranged in order of increasing $MgCO_3$ content. The relationship between $MgCO_3$ content and intensity of the dolomite line at 2.89 A. is shown in Fig. 1. It would appear that use of such a curve

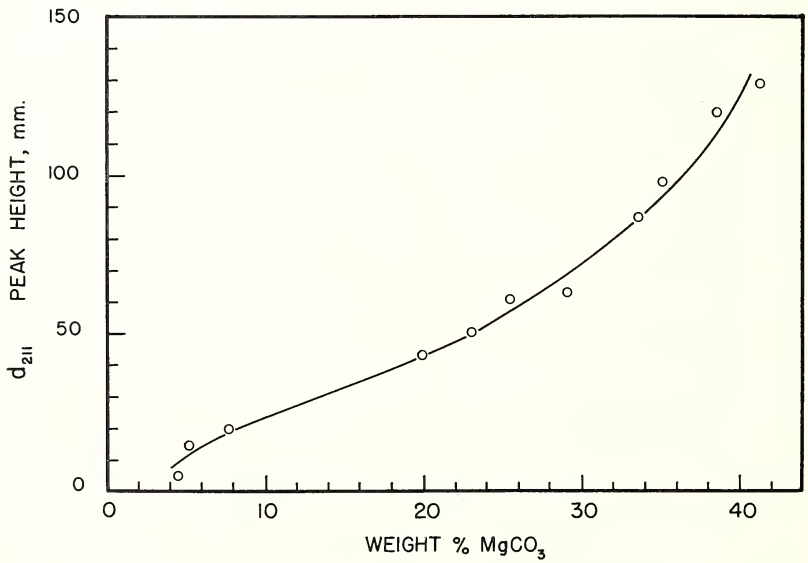

FIG. 1. Variation in the intensity of the d_{211} line of dolomite as a function of the weight percent $MgCO_3$ in limestone.

would give semiquantitative results for the $MgCO_3$ content of high purity limestones.

The increase in slope of the curve with increase in $MgCO_3$ is probably related to the difference in the mass absorption coefficients of Ca and Mg for Cu Kα radiation. The mass absorption coefficient of calcium is 172 while that of magnesium is only 41. Thus, as the calcium content of the lime-

TABLE 1. Chemical and x-ray diffraction data for selected limestones.

Lab. No.	Source	County	Percent $CaCO_3$	Percent $MgCO_3$	d_{211} Dolomite A	d_{211} Dolomite Int.[1]	Mole Percent $MgCO_3$ in Dolomite[2]
36	Dunn Limestone Co.	Owen	95.5	0.7	——	——	——
54	Calcar Quarries	Orange	90.4	1.4	——	——	——
955	Cloverdale Stone Co.	Putnam	93.3	2.4	——	——	——
39	Ralph Rogers and Co.	Lawrence	89.9	4.5	2.891	4.5	49.5
55	William Cave	Orange	87.7	5.1	2.904	14.0	45.5
43	Hoosier Lime and Stone Co.	Washington	87.6	7.7	2.886	20.0	51.7
1283	Lynn Stewart	Bartholomew	75.7	19.9	2.888	43.0	51.0
1281	Paul Frank	Jennings	70.4	23.1	2.886	50.0	51.7
1261	Standard Materials Corp.	Madison	65.9	25.5	2.884	61.0	52.5
1282	Lynn Stewart	Bartholomew	62.7	29.1	2.893	63.0	49.3
100	Francisville Stone Co.	Pulaski	55.5	33.6	2.889	87.0	50.7
1289	McCorkle Stone Co.	Rush	59.6	35.1	2.884	98.0	52.5
1051	Erie Stone Co.	Wells	55.2	38.5	2.889	120.0	50.7
1306	DeKalb County Co-op. (Supplier—Ohio Lime Co.)	Sandusky (Ohio)	56.1	41.3	2.882	129.0	53.0

[1] Peak height in mm.

[2] Estimated from data of Goldsmith and Graf (4, Fig. 1).

stone decreases the intensity of the dolomite diffraction line will increase disproportionately. Taking the mass absorption coefficient of ideal dolomite

$$\left(\frac{\mu}{\rho}\right)_{Ca_{0.5}Mg_{0.5}CO_3}$$

as a base an intensity correction factor for the 2.89 A. dolomite line may be computed for limestones containing less than 0.50 mole fraction of Mg by determining the ratio of the mass absorption coefficient of the high-calcium limestone to that of the ideal 1:1 dolomite. Thus

$$\frac{\left(\frac{\mu}{\rho}\right)_{Ca_{0.8}Mg_{0.2}CO_3}}{\left(\frac{\mu}{\rho}\right)_{Ca_{0.5}Mg_{0.5}CO_3}} = \frac{65.6}{49.9} = 1.31$$

When these corrections are applied, the relationship between intensity and $MgCO_3$ content becomes more nearly a linear one. The correlation coefficient for this relationship was 0.980 (Fig. 2).

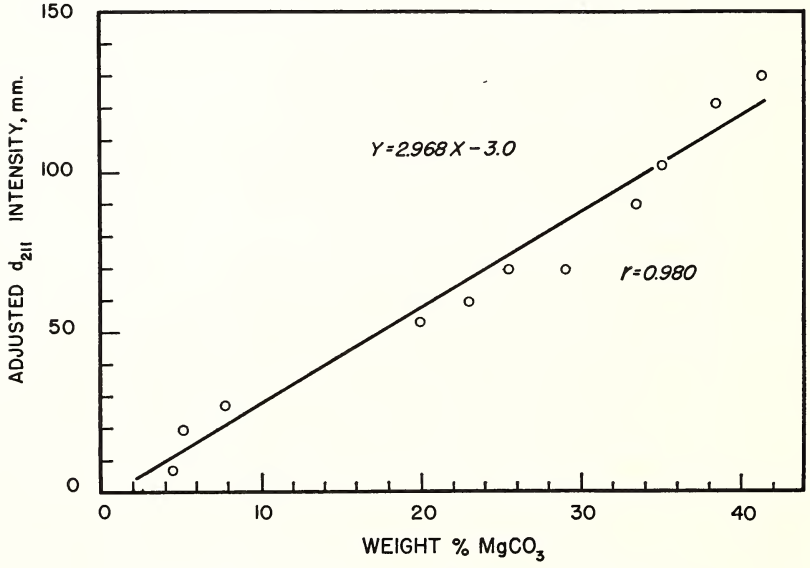

FIG. 2. Relationship between the adjusted intensity of the d_{211} line of dolomite and the weight percent $MgCO_3$ in limestone.

The mole percent $MgCO_3$ in the dolomite, as estimated from the d_{211} value (4), varies from 45.5 to 53 percent. That this is a real difference is illustrated in Fig. 3 in which the d_{211} peaks of two dolomites show a difference of 0.020 A. The d_{211} for sample No. 55, which contains 5.1 per-

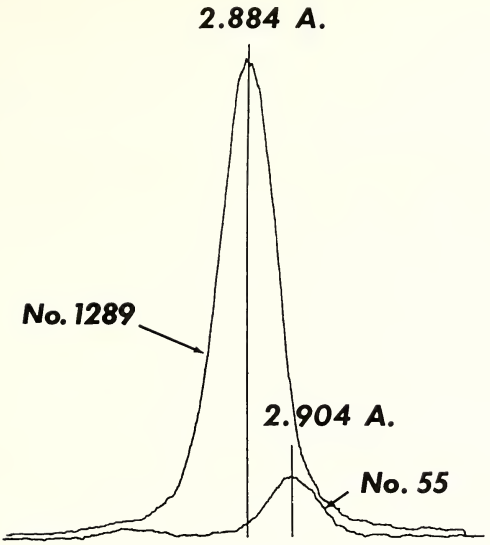

FIG. 3. A portion of the diffractometer tracing for samples No. 55 and No. 1289 showing a difference of 0.02 A. in the d_{211} values.

cent $MgCO_3$, is 2.904 A., indicating the presence of Ca^{++} ions in the planes of Mg^{++} ions.

The d_{211} values for calcite indicate a maximum of 3 to 3.5 mole percent $MgCO_3$. This is in agreement with the results of Goldsmith, Graf and Joensuu (2).

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ZOOLOGY

Chairman: FORST FULLER, DePauw University

CARL KREKELER, Valparaiso University, was elected chairman for 1960

ABSTRACTS

Some Factors Influencing the Lethal Temperature of *Musca domestica*. FORST D. FULLER, DePauw University.—The experimental animals, *Musca domestica*, were exposed to elevated temperatures at two widely varying relative humidities. The exposure of the flies for a 15 minute period at the higher relative humidity resulted in 100% fatalities with the temperature between 48.1 and 49.2°C. In dry air however the lethal temperature was found to be between 56.5 and 57.0°C. The flies exposed to the dry air showed a consistent loss of weight in direct proportion to the temperature. In order to rule out the role of water evaporation as a mechanism of increased heat tolerance animals were submerged in a water bath. At a temperature of 45.5°C 95% of the flies died after an exposure of only 10 minutes. This rather sharp fall in the maximum lethal temperature might be explained on the basis of either the elimination of water evaporation as a mechanism to maintain a lower body temperature or the possible toxic effects of certain metabolites which would tend to accumulate under these anaerobic conditions.

Locomotion and Oxygen-Consumption Rhythms in *Uca pugnax*.[1] WILLIAM J. BRETT, Indiana State Teachers College.—Crabs collected weekly were subjected in the laboratory to either normal light-dark changes or to reversed light-dark conditions. Both control animals and light-reversed animals were set up in respirometers and activity recorders maintained in constant low illumination. Averages for 12 to 14 crabs were used for all hourly values. The data were analyzed for possible solar and lunar cycles. Analysis of the daily records for oxygen-consumption and locomotion in controls and reversed crabs showed a lunar cycle with two peaks generally 12 to 13 hours apart. The peaks move across succeeding solar days at an average tidal rate. In the controls the major peak was the one occurring nearer to 12 midnight; whereas, in the experimentals the major peak was the one occurring near 12 noon. The mean lunar cycle for the 29-day period revealed little if any difference between the controls and reversed animals in either oxygen-consumption or spontaneous activity. In oxygen-consumption one maximum occurred at lunar zenith in controls and experimentals, and the second occurred at lunar zenith in the controls and 2 hours before in the experimentals. For locomotion the maxima for controls and reversed animals occurred 2 hours before zenith and 2 hours before nadir. The form of the average diurnal cycle for both locomotion and respiration for the 29-day period between

[1] This study was aided by a contract between the Office of Naval Research, Department of Navy, and Northwestern University, NONR-122803.

July 21 to August 18, 1959 was just the reverse for the controls and the experimentals. In the controls the maximum for locomotion occurred at 1 P. M. and for respiration at 3 P. M. Using a 2-hour locomotion lead over oxygen consumption, a coefficient or correlation of +.894 (N = 24) between the control animals and +.778 (N = 24) between the reversed animals for the average diurnal cycle indicates that locomotion produces a considerable effect upon the form and amplitude of the oxygen-consumption cycle.

Bottom Types and Bottom Organisms of the Saint Joseph River Drainage in Indiana. CLARENCE F. DINEEN, Saint Mary's College.—A qualitative analysis and quantitative estimate of the bottom organisms and the types of bottom in the main stream and the chief tributaries based on collections from over 50 areas. Quadrats and dredges were used. Collections were taken in June and in August. Interpretations as to the future changes in populations which might be expected and as to possible potentials of the drainage system to support organisms are made. The study suggests a general trend toward better conditions (in terms of sanitation and of recreational uses) for desirable plants and animals.

Range Extension of the Allegheny Woodrat *(Neotoma magister)* in Indiana. WILLIAM J. WAYNE, Indiana Geological Survey.—Presence of the Allegheny woodrat (*Neotoma magister* Baird) in Indiana was first authenticated from specimens collected at Tobacco Landing, south of Laconia, Harrison County in 1930. It has also been reported from other counties along the Ohio River near this locality. No records have been published that indicate its presence farther north of the Ohio River.

During the fall and winter of 1958 a burrow surrounded by a pile of clay pellets and limestone fragments appeared in the corner of my garage, which is located in a hilly wooded area near the west edge of the Mitchell Plain, 5 miles southwest of Bloomington. Although the animals did not enter live traps, I was able to identify them tentatively on the basis of their nocturnal habits, fecal pellets, and character of the entrance to the burrow, and a few observations by flashlight.

After repeated failures to attract the rodents into live traps, I tried pouring water into a burrow. A few days later, on July 2, 1959, three suckling young were found lying dead on the ground about 40 feet from the burrow entrance. Each had been killed by a bite in the flank. An unbaited snap trap in the entrance to the burrow caught a female two nights later when she brushed it with a piece of bread she had carried from a compost pile. With her capture, the identification of *Neotoma magister* was confirmed. More recent observations indicate that additional animals are still present in the same group of burrows, but so far no other colonies have been noted in the neighborhood. This may be a single isolated colony or it may represent a true range extension; in either event, the area between Monroe and Harrison Counties should be checked for presence of the species.

Ethanol Permeation of Frog Muscle Cells; Energetic Interaction with the Membrane. WILLIAM K. STEPHENSON, Earlham College.—Traditionally ethanol has been presumed to penetrate living cells by passive diffusion. There are, however, two lines of evidence for postulating that, in

frog muscle, ethanol enters the cells by an interaction with the plasma membrane.

Frog sartorius muscles were soaked for ca. 2 hours in Ringers fluid with varying amounts of ethanol added. When weight changes are plotted against time the slope of the resulting curve is a measure of the rate of ethanol entry. Slopes plotted against the percent of ethanol added to the Ringer give a curve which exhibits a plateau between 5 and 9 percent. The plateau suggests that a site of entry of ethanol becomes saturated over this concentration range, and indicates a chemical combination with the membrane. This conclusion is corroborated by the observation that the temperature coefficient (Q_{10}) of ethanol penetration at 7 percent added to Ringer is about 2. A temperature coefficient of this magnitude is characteristic of a chemical reaction rather than a physical process like diffusion.

The Use of Inexpensive Substitutes for Elaborate Equipment in the Zoology Teaching Laboratory. J. D. WITHERSPOON and R. H. WITHERSPOON, Purdue University.—Instructors and students in colleges and high schools with limited budgets can construct simple teaching devices which duplicate, in principle, the expensive originals. A few of those useful in teaching respiration will be considered: (1) a beach ball and dust mask to replace the Douglas bag, (2) a milk bottle oxygen consumption chamber, (3) a Warburg-like device for measuring tissue metabolism, and (4) the filter pump aspirator for decompression studies.

The Influence of Hypothermia and Oxygen on Survival of Mice Following Bilateral Carotid Ligation. J. D. WITHERSPOON and W. A. HIESTAND, Purdue University.—We have previously reported that hypothermia increases tolerance to explosive decompression but not to decompression at 100 mm Hg/min. The reduction of respiratory capacity in hypothermia seemed to prevent mice from adapting to a slower onset of hypoxia. It was reasoned that oxygen might increase survival of hypothermic mice in which both carotid arteries were ligated. Accordingly, four groups with twenty animals in each group were subjected to the following treatments: (1) untreated controls, (2) controls plus 100% oxygen, (3) chlorpromazine hypothermia, and (4) chlorpromazine hypothermia plus 100% oxygen. In each of the first three groups only four out of twenty mice survived for a two hour time period, but in the combination of hypothermia plus 100% oxygen, seventeen out of twenty animals survived for two hours.

Cytology of the S913 Transplantable Lymphosarcoma. AARON K. WARREN, Indiana University Medical School.—Chromosome counts of the S913 lymphosarcoma, a transplantable tumor growing in C57BL/10 mice, have been made to determine the population structure of the tumor. The stemline of this tumor is in the range of 60-75 chromosomes. A morphological study of the chromosomes has revealed marker chromosomes typical of this tumor.

Earthworms of the Upper Whitewater Valley[1] (East-Central Indiana)

James W. Joyner, Pleasant View Junior High School, Richmond

Introduction

Despite the ubiquity of earthworms as soil inhabitants and their extensive use as fish bait there has been very little investigation of their distribution, natural history and ecology. In 1914 Heimburger (9) published the only regional paper on the earthworm fauna of Indiana. He presented a preliminary list of 14 species.

This paper, while local in scope, is presented as the second contribution to the knowledge of the earthworm fauna of Indiana. The species listed herein include five not found by Heimburger but expected as they have been reported in regional papers from surrounding states. A sixth and unexpected species, *Eisenia carolinensis*, has hitherto been reported from only North Carolina, Virginia and Louisiana.

The collections of earthworm specimens upon which this paper is based were obtained during the summers of 1957, 1958 and 1959 in the Upper Whitewater Valley. For the purposes of this paper the area of the "Upper Whitewater Valley" is defined as that part of the Whitewater drainage basin which is north of Union County, Indiana. This includes all of Wayne County and parts of Henry and Randolph Counties, Indiana. It also includes small portions of Preble and Darke Counties, Ohio.

Since all but the strictly aquatic Oligochaetes are commonly termed "earthworms" I did not restrict my collecting to the soil dwelling species. Species characteristically found in such microhabitats as stream edges, manure piles, compost heaps, and forest litter were also obtained. Collections of soil species were obtained by digging and sorting cores of earth to a depth of one foot.

The study was hampered because collections had to be made during the summer when many species are quiescent instead of during the spring and late fall when earthworms are most active. However the list of earthworms presented here, when compared with those published from surrounding states, indicates that only a few known species remain to be found. Moreover, a faunistic survey would seldom, if ever, be considered complete because of the inevitable introduction of new species by the multifarous activities of man.

Taxonomy, Nomenclature and Identification

The particular arrangement of families and genera followed in this paper is from Stephenson (13). For identification of species I used Smith (12), Olson (11) and Gates (8). The nomenclature corresponds to that listed in Gates (5).

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[1] This study was supported by the Charles F. Kettering Foundation through the Soil Research Program of Earlham College. I wish to thank Dr. Leland Chandler of Purdue University for confirming the identification of *Eisenia carolinensis* and for other courtesies extended to me.

There are a number of current taxonomic problems relating to the classification of earthworms. These problems will be dealt with later in the notes concerning the various species listed.

A conservative arrangement and listing of earthworms species has been followed in this paper. For instance, *Diplocardia* is identified to genus only; no formae of *Allolobophora caliginosa* are included; and specimens which might have been termed *Bimastos gieseleri* by some authors are listed as *Bimastos tumidus* because diagnosis failed to clearly indicate to which species they belong.

LIST OF EARTHWORMS

Family: Megascolecidae

Genus: *Diplocardia*

As stated above, this genus was not identified to species. I was thwarted by the unresolved taxonomy and the inherent difficulties involved in identifying diplocardian species.

Diplocardia is a distinctly endemic genus of earthworm. It is limited to North America and has been reported from a large number of states. Heimburger (9) reported four species from various counties of Indiana.

In this study they were found to be soil species often occurring at depths of six to twelve inches. None was found associated with concentrations of organic matter.

Diplocardia spp. appeared in 22 of the 71 collections making it one of the four most common earthworms in the area in terms of the number of times it was collected. (See Table 1.)

Family: Glossoscolecidae

Genus: *Sparganophilus*

Sparganophilus eiseni Smith, 1895—This genus of earthworm is endemic to North America. Smith (12) states that *S. eiseni* is abundant in the mud of the bottom and margins of many rivers and lakes east of the Mississippi River. Heimburger (9) reported it from Fulton and Marshall Counties in the northern part of Indiana.

My specimens of this limiculous earthworm were collected from a muddy flat along Clear Creek upstream from West Test Road bridge. The mud was rich in organic matter and chemical analysis disclosed 4.3 percent organic carbon. There was no growing vegetation where the worms were found nor was the site under water.

Their presence along this stream has been known for several years. (Oral communication, Dr. Murvel Garner.)

Family: Lumbricidae

Genus: *Eiseniella*

Eiseniella tetraedra (Savigny) 1826 forma *typica* Michaelsen, 1900—This peregrine species has attained wide distribution through inadvertent introduction by European settlers. It is reported in nearly all state lists of earthworm fauna.

However, it is scarcely an abundant earthworm as its habitat seems to be limited to wet soils of high organic content. I collected specimens

from an aquatic habitat in a greenhouse, near a sewage overflow stream and from a woodland site.

In faunistic studies from surrounding states the closely related *Eiseniella tetraedra* forma *hercynia* has been reported in association with forma *typica* which differs from the former in a two segment anterior displacement of the spermaducal pores. In this study none of forma *hercynia* was found, however they are to be expected.

Genus: *Eisenia*

Eisenia carolinensis Michaelsen, 1910—This species of earthworm has an interesting history. It was discovered and named by Michaelsen who intercepted it in a shipment of plants received at Hamburg from Fayetteville, North Carolina. The species remained in oblivion from then until 1955 when Gates (8) published a report on collections from North Carolina, Virginia and Louisiana.

Eisenia carolinensis is reported for the first time for Indiana and for the areas west of the Appalachians. Two large clitellate specimens were collected from different sites in Lewis' Woods near Williamsburg, Indiana. This woods is considered a "virgin type" forest and has been used by Earlham College for various soil and ecology studies. There is no evidence such as dumped fish bait that can account for the presence of this species. Extensive digging on the collecting sites has failed to turn up additional specimens.

This species can also be reported from Lawrence County, Indiana where it was collected on the north bank of the White River near the river bridge on the Buddha-Lawrenceport Road. Here in July of 1957, '58, and '59 collections of 20-30 specimens were made. The worms were quite active and showed no signs of a quiescence. Of the specimens collected only five were clitellate. A few were aclitellate while many were large (10-12 cm. long) but juvenile, i.e. showed no sign of sexual maturity. Identification was based on a diagnosis of the clitellate specimens. It was possible, in this case, to separate *E. carolinensis* from other species because their posterior 30-40 segments are characteristically square in cross-section while alive.

The presence of this species along a river bank may be anomolous because of the possibility of their having been introduced by fishermen.

Eisenia foetida (Savigny) 1826—The manure worm or brandling is abundant throughout Europe and wherever Europeans have settled. It is widely distributed throughout the United States.

Eisenia foetida restricts itself to areas of organic wastes and seldom ventures into the soil. Occasionally one will be found under the bark of a rotting log. The fact that this earthworm thrives in culture beds has made it the worm one is most apt to buy for fish bait. The ease with which they are propagated has led to their sale among organic gardening faddists. It is debatable, however, whether they have any ability to amend the soil as they do not naturally occur there.

My specimens were collected from a pile of rotting cow manure (the worms avoided the fresh manure) and from coarse gravel in the bed of an intermittent raw sewage stream.

Though the collections of *E. foetida* were limited to two, with occasional specimens appearing in other collections, there is no doubt that they

could have been found on virtually any farm where livestock wastes were permitted to accumulate.

Eisenia rosea (Savigny) 1826—This European peregrine is widely distributed in North America. It is reported from eastern Canadian provinces, Maine, Massachusetts, New York, Ohio, Indiana, Illinois, Missouri, Louisiana, Georgia, Arizona, California, Lower California, Connecticut, Michigan, Arkansas and Oklahoma.

An examination of descriptions of my collecting sites discloses a wide variety of habitats. It is a soil species and is often found in asociation with *Allolobophora caliginosa, Lumbricus rubellus* and *Lumbricus terrestris.*

In the summer it is quite commonly found in a quiescent state; balled up in the soil within a foot of the surface.

This species was the only one in which insect parasitization was noted. Dipteran larvae probably of the cluster fly, *Pollenia rudis,* were found in three *E. rosea* collected in a chicken yard near a dwelling.

Genus: *Dendrobaena*

Dendrobaena octaedra (Savigny) 1826—This species, of European origin, is reported from a few states. These include Ohio, Illinois, Colorado, Washington, New York, and Michigan. It is reported from Indiana for the first time.

Only one site is reported for the collection of this species. The extent of the area over which they could be found within an unpastured dry hillside woods was not investigated.

In this instance they can be termed a woodland species which prefers the litter and A_1 horizon of the soil. It was found in association with *Octolasium lacteum* which was being collected for a feeding experiment.

Dendrobaena subrubicunda (Eisen) 1874—This species is widely distributed in Europe and various parts of the world. In North America it has been reported from eastern Canadian provinces, Massachusetts, New York, Ohio, Indiana, Missouri, Colorado, California, Louisiana, Illinois, and Arkansas.

Small and pigmented, *D. subrubicunda* was found in abundance in a compost pile which received garbage and weeds. They were first found in the pile during the extremely wet summer of 1958. Examination of the site a year later on June 19, 1959 disclosed the material in the pile was quite dry and contained no earthworms. Olson (11) noted their presence in areas of sewage contamination associated with *E. foetida* so it is presumed that they may be expected wherever concentrations of organic waste exist.

Ten specimens were collected in association with *Bimastos tumidus, Eisenia rosea* and *Octolasium lacteum.*

Genus: *Allolobophora*

Allolobophora caliginosa (Savigny) 1826—This species is credited by Stephenson (13) with being the commonest of all earthworms taking the whole world into consideration. It has attained a world wide distribution and it is not necessary to list here the places it has been found.

A. caliginosa appears as the most abundant earthworm in my collections as it occurs in 60% of them. (See Table 1.)

TABLE 1

Relative abundance of species as indicated by a comparison of the number of times contained in collections and the total number collected

	Species	Times	pct. total (70)	Number	pct. total (800)
1.	*Allolobophora caliginosa*	42	60	245	31
2.	*Octolasium lacteum*	32	46	138	17
3.	*Diplocardia spp.*	22	36	86	11
4.	*Lumbricus rubellus*	21	30	134	17
5.	*Eisenia rosea*	14	20	31	4
6.	*Allolobophora chlorotica*	7	10	30	4
7.	*Eisenia foetida*	5	7	27	3
8.	*Eiseniella tetraedra* forma *typica*	5	7	9	1
9.	*Sparganophilus eiseni*	2	3	50	6
10.	*Lumbricus terrestris*	2	3	8	1
11.	*Eisenia carolinensis*	2	3	2	0.25
12.	*Dendrobaena octaedra*	1	1.4	15	2
13.	*Dendrobaena subrubicunda*	1	1.4	9	1
14.	*Bimastos tumidus*	1	1.4	5	0.6
15.	*Bimastos tenuis*	1	1.4	3	0.4
16.	*Bimastos longicinctus*	1	1.4	1	0.12

Eaton (2) has stated that it is "the most abundant, wide spread and ecologically adaptable species in the United States." Soil and a reasonable amount of moisture seem to be the only requisites for the presence of this species. I find as did Murchie (10) that "it was not taken from manure, nor has it been found in truly aquatic habitats."

In view of certain complications concerning classification I have chosen to list my specimens belonging to the "caliginosa complex" as *Allolobophora caliginosa*. [For information concerning the classification complications see: Cain (1), Evans (3, 4), and Gates (6, 7).]

Allolobophora chlorotica (Savigny) 1826—Another of the European earthworms which has invaded North America, it has been reported from the eastern Canadian provinces, New York, Ohio, Indiana, Illinois, Missouri, District of Columbia, North Carolina, Colorado, California, and Michigan.

This greenish worm has a sluggish behavior and is usually contorted when removed from the soil. It is found in wet and usually highly organic or polluted soils. However, I found it on two occasions in association with *L. terrestris* in home gardens.

Genus: *Bimastos*

Bimastos tumidus (Eisen) 1874—This species has been reported only from New York and Ohio. It is reported from Indiana for the first time. The absence of this species from reports may be due to the class similarity

between this species and *B. gieseleri* (Ude) 1895 and *B. gieseleri* var. *hempeli* Smith 1915. The latter have been reported from five states.

Smith (12) suggested the possibility that *B. tumidus* and *B. gieseleri* may be identical so I chose to list my specimens as *B. tumidus* since a diagnosis of characteristics failed to clearly indicate to which species they belonged.

Bimastos longicinctus Smith and Gittens 1915—To date this species has been reported from Illinois, Ohio, Arkansas and Michigan. It is reported from Indiana for the first time.

Although Smith (12) stated that this species occurs abundantly in the soil of lawns and parks and nearby woods of Urbana, Illinois, it has not been reported as abundant in any other localities where it has been found.

I can report only one specimen. It was found in a chicken yard where *Allolobophora caliginosa* are abundant in season.

Bimastos tenuis (Eisen) 1874—Smith (12) pointed out that, "of the genus *Bimastos* only *B. tenuis* has attained anything like world wide distribution. All the other members of the genus are presumably indigenous and form a quite homogenous group." It has been reported from all parts of North America.

Heimburger (9) reported this species, as *Helodrilus constrictus*, from under logs near Culver. My single collection of three specimens was taken in Lewis' Woods. Murchie (10) noted that it prefers the litter of forest soils but will also be found near the surface in moist stream bank soils.

Genus: *Octolasium*

Octolasium lacteum Orley 1881—This worm is widely distributed in Europe and has been reported from many sectors of the United States. Gates (5) lists it for New York, Ohio, Illinois, Indiana, Missouri, Colorado, California, Mexico, and Massachusetts. More recently it has been reported from Michigan and Arkansas.

An examination of my collecting data indicates that it prefers organic conditions with some moisture stability. Nearly all my collections were made in woodland. The remainder were from alluvium, peat, and polluted soil.

It is interesting to note that this species is greatly disturbed by digging and can often be made to surface by shaking a spade embedded in the soil.

Genus: *Lumbricus*

Lumbricus rubellus Hoffmeister 1843—This peregrine species has found its way to most areas of North America and is reported from eastern Canada, Massachusetts, New York, Ohio, Missouri, Michigan, Washington, Oregon, California and Arkansas. It is reported from Indiana for the first time.

According to a local bait dealer this species known as the "red leaf worm" is preferred by him and he does not handle the "stinkin" *Eisenia foetida*. This worm would rank second in prevalence and is the one quite commonly found crawling in the street after heavy rains. It prefers a concentration of organic matter such as buried or rotting leaf litter. Polluted soils are also good places to find *L. rubellus*. I found in one

instance a tremendous concentration of this species in gravel soaked with raw sewage effluent.

Lumbricus terrestris Linnaeus, 1758 (part) Muller 1774 (part)—This well known, large earthworm is another European peregrine which has attained wide distribution. It is reported for the first time from Indiana where it is, no doubt, widely distributed over the state.

In my experience the habits of *L. terrestris* are slightly different from other soil species. They are seldom taken in digging during the summer because they retreat into their long deep tunnels. In certain seasons they may be found under boards or other trash on the surface of the soil. Evidences of their presence are the characteristic middens of leaves and leaf petioles with which they may cover their burrow openings.

The presence of eight *L. terrestris* in my collections is no indication of relative abundance. It only indicates they were not found with the methods of collecting used.

Summary

The investigation reported here concerns a survey of earthworm fauna of the Upper Whitewater Valley (East-central Indiana) carried out during the summers of 1957, 1958 and 1959.

A conservative approach to the listing of species has been followed.

Sixteen species are reported for the survey area. Six of these are new records for the state.

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The Introduction of the San Juan Rabbit *(Oryctolagus cuniculus)* in Indiana

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Introduction

The European rabbit *(Oryctolagus cuniculus)* was established in the San Juan Islands, Washington, prior to 1900 (3). Following the end of World War II, at least two Friday Harbor, Washington dealers trapped or netted San Juan rabbits for shipment to propagators in Eastern and Midwestern States. Indiana sportsmen began importing and liberating these rabbits in 1949. The Indiana Department of Conservation had no control over the indiscriminate importation, propagation, and release of this rabbit until the passing of a 1953 law by the State Legislature. This law made it illegal to buy, sell, or trade wild rabbits, but it has not been enforced. By the mid-1950's several individual biologists and various farm groups were disturbed by the San Juan rabbit introductions. Latham (8), speaking to the Twentieth North American Wildlife Conference, expressed his growing fear of the possible consequences of these introductions in the Eastern and Midwestern States. Barnes (2), speaking on this subject to the Seventeenth Midwest Wildlife Conference, concluded that studies should be initiated in an attempt to better understand the problems presented by the propagation of this animal. Farmer delegates to the 1955 convention of the Indiana Farm Bureau, Inc. adopted the resolution as follows: "Resolved that the possession of, breeding or distribution of San Juan rabbits be prohibited" (10).

In Indiana, those who hunt with beagle hounds (beaglers), refused to believe that this rabbit was capable of the damage attributed to it in other parts of the world. They thought it to be a superior game animal to our native cottontail *(Sylvilagus floridanus)* (9). Holcombe (4), writing in a nationally distributed beagle magazine, expressed the opinion that "the San Juan is not a menace to the farmer" and "he is not the same rabbit that spread over all Europe and Australia. . . ." The attitude of the average sportsman was probably best expressed by an anonymous author writing in the January, 1955, Washington State Game Department Game Bulletin. He stated, "And to assume, as some persons have, that America's agricultural economy is menaced by our San Juan bunnies, borders on the fantastic" (1).

The Indiana Department of Conservation began a study of the San Juan rabbit in August, 1956, before doing more than making news releases discouraging the propagation and release of this rabbit. Among the objectives of this study were the determining of the origin and background of the San Juan rabbit and recording of its introduction in Indiana.

Methods

Library sources were searched for references to *Oryctolagus cuniculus*. Correspondence was carried on with investigators working with this species in Great Britain, New Zealand, Australia, and California.

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[1] This investigation was made while employed as a Study Leader, Pittman-Robertson Project W-2-R, Indiana Department of Conservation.

Indiana propagators of San Juan rabbits were located by following leads furnished by conservation officers and sportsmen. Propagators were interviewed between September 24, 1956, and March 9, 1959, to determine the extent and success of San Juan liberations. I investigated all reports received by the Indiana Department of Conservation of established populations of wild San Juans.

Findings and Discussion

The San Juan rabbit is a variety of the European rabbit. Rabbits of this species have been introduced in various parts of the world and have caused agricultural damage wherever they have become established. Liberations were by far the most successful in Australia. The damage sustained by the natural communities of Australia provides the classic example of the dangers inherent in the transplantation of wild mammals or birds.

Rabbit hunters and beaglers are the major groups who have propagated San Juan rabbits in Indiana. Most propagators live in areas that are heavily industrialized, or where intensive farming is practiced. These land uses restrict the suitable cottontail rabbit habitat. The presence of a dense human population with its varied interests further reduces the number of cottontail rabbits available to the sportsman by closing to public hunting a portion of the remaining habitat. Cottontail rabbit numbers are subject to fluctuations that, over a period of years, are apparent and measurable. This combination of factors causes concern among rabbit hunters and beaglers. They turned to the propagation of the San Juan in an effort to solve the problem of rabbit scarcity.

Propagators are able to raise San Juans in captivity, using domestic rabbit raising techniques. Breeding stock no longer has to be imported since at least 202 breeders were being held by propagators during February and March, 1959 (Table 1).

A Marion County beagler began liberating San Juan rabbits in 1949. During the following ten years, at least 155 propagators released not fewer than 6,326 San Juans in 50 Indiana counties. Table 1 includes the numbers of rabbits released and the number of propagators in each county. All totals must be considered as minimum, since it is possible that all propagators were not found and interviewed.

Release techniques varied. Many rabbits were liberated and then left to fend for themselves. Others were carefully supplied with water, feed, and salt. Predator control was sometimes practiced on release sites. The liberated rabbits soon disappeared regardless of the release techniques employed, however.

The San Juan rabbit is not now established in Indiana primarily because of the lack of suitable habitat. Howard (5) (6) and Watson (11), who have studied this rabbit in Australia and New Zealand, agree that optimum habitat includes extensive areas of short grass interspersed with bare ground. These conditions were created in New Zealand by a combination of over-grazing by livestock and improper burning of the pastures. Rabbits were able to assist in the maintenance of these cover conditions, after their establishment, by burrowing and grazing. The rank growth

TABLE 1

San Juan Rabbit Propagation by County[1]

County	Number of Propagators	Rabbits— Total Held 1959	Total Rabbits Released
Adams	1	0	9
Allen	3	0	184
Bartholomew	6	6	240
Brown	3	0	174
Cass	1	0	0
Clark	2	6	9
Clay	5	25	317
Daviess	2	0	226
Dearborn	2	0	130
Decatur	3	0	63
DeKalb	2	11	90
Delaware	3	9	211
Dubois	4	0	109
Fayette	2	0	80
Franklin	5	0	130
Gibson	7	16	164
Greene	4	0	399
Hamilton	9	0	498
Hancock	10	65	404
Henry	4	0	237
Howard	1	0	4
Huntington	1	0	42
Jay	2	3	1
Jennings	2	2	0
Johnson	3	0	50
Knox	2	0	58
Lawrence	2	6	30
Madison	7	5	481
Marion	3	0	310
Marshall	4	3	379
Martin	1	0	250
Morgan	1	0	36
Owen	2	0	0
Parke	1	10	30
Pike	11	0	281
Porter	4	0	49
Putnam	1	0	0
Randolph	2	24	51
Ripley	1	0	40
Rush	2	0	17
St. Joseph	4	0	23
Shelby	4	0	48
Sullivan	2	0	38
Union	2	0	56
Vigo	3	0	93
Warrick	1	0	0
Washington	2	0	31
Wayne	3	9	111
Wells	2	2	107
Whitley	1	0	36
Totals	155	202	6,326

[1] This table includes both San Juans and San Juan X domestic rabbits. All numbers and totals must be considered as the minimum.

of grass, forbs, and woody vegetation in Indiana has not allowed the establishment of this rabbit.

Released San Juans have persisted longer in Indiana barnyards than in the pastures, croplands, or timbered areas because of the presence of a variety of cover and food. Corn in cribs is usually accessible to them and board piles or buildings are available for cover. Reproduction occurs, but the young are usually killed by domestic cats and dogs after they leave the nest. Adult San Juans are not generally preyed on by these species since escape cover is usually available.

Both adult and young San Juans are vulnerable to predation on release sites away from farm buildings. Major predators include great horned owls *(Bubo virginianus)*, and domestic dogs and cats. Road-killed San Juans are often found near release sites. Young rabbits kindled in burrows on poorly drained release sites may drown during periods of moderate to heavy rainfall.

The virus-caused disease, myxomatosis, has been introduced in Europe, Great Britain, and Australia to aid in the control of this rabbit. It has also been reported in California where it has produced mortality among domestic rabbits *(Oryctolagus cuniculus)*. The continued importation and liberation of San Juan rabbits invites the introduction of this disease into the commercial rabbitries of Indiana. Two external rabbit parasites, not previously known to occur in this state, have been found on San Juans held by Indiana propagators (7).

I recommended (7), to the Indiana Department of Conservation, the adoption of a policy aimed toward the elimination of San Juan rabbit propagation in this state. In the absence of optimum habitat, additional San Juan liberations will probably merely waste the propagator's money. The possibility remains, however, that populations may become established in marginal habitats, needlessly exposing our native wildlife and agricultural economy to competition with this exotic species.

Summary

Indiana sportsmen began importing and liberating the San Juan rabbit *(Oryctolagus cuniculus)* in 1949. The release of this rabbit in Indiana's game coverts caused concern among biologists and farmer organizations, since it has become a problem species wherever it is established. An investigation, conducted by the Indiana Department of Conservation, found that more than 6,000 San Juan rabbits have been liberated in at least 50 Indiana counties. This rabbit is not now established in Indiana because of the lack of suitable habitat. Recommendations were made to the Indiana Department of Conservation advising the prohibition of further rabbit importations and the strict control of San Juan rabbit propagation in this state.

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Age Changes in the Liver as Studied by Light and Electron Microscopy

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The subject of the intimate nature of the changes which occur during the aging process has become one of increasing interest, partly due to the very practical fact that the percentage of individuals in our population 65 years of age or over is increasingly greater. For a number of years our own research efforts have been directed toward study of the histological or tissue changes in various organs with age in pedigreed animals. In previous papers we have described the histological changes (2, 3, 4). In collaboration with workers in other laboratories we have been able also to show a correlation between the chemical and the histological changes which occur in some tissues with age (5).

More recently, we have become interested in the cellular or cytological changes with age and are attempting to study the various organelles of the cell. Our present studies are being made on mice of the C57 Black strain. Both the classical cytological methods with light microscopy and the newer method of electron microscopy are being used and we are making an attempt to correlate the two where possible.

The liver is an organ in which the age changes as seen by histological or tissue study are relatively inconspicuous. There is very little fibrotic change in the liver of a senile animal. In some other organs, as in the thyroid gland, for example, fibrosis is a conspicuous change in old age, while in the parotid gland, fatty degeneration is common (2, 3). The picture of the liver on the other hand, its multitudes of hepatic cells with their many different functions, and the hepatic trinities, the bile duct, artery and vein, is generally fairly similar in young and old animals under low powers of the microscope. The tissue changes which occur in the liver in old age are primarily those of what may be called lymphocytic infiltration or the appearance of new lymphoid tissue. This we have called ectopic lymphoid tissue or lymphoid tissue in an abnormal place.

In the present study ten pedigreed mice of the C57 Black strain, from the Roscoe B. Jackson Laboratory, were used. The individuals according to age in days and sex were as follows: 105 ♂, 105 ♀, 539 ♂, 539 ♀, 549 ♂, 549 ♀, 610 ♀, 664 ♂, 664 ♀, and 664 ♂. We have represented here, then, young adult animals, animals of "late middle age" (539-549 days) and animals which may be considered "old" or senile, over 600 days of age, since the life span of the mouse is about two years.

The animals were sacrificed by use of ether. Very small portions of liver, about 1 mm. in diameter, were fixed in Palade's fixative, osmic acid buffered with veronal acetate, embedded in a 4:1 mixture of butyl-methyl methacrylate, sectioned with a glass knife on a Porter-Blum ultramicrotome and mounted on 200 mesh grids. Only sections in the silver-gold range were used. Larger pieces of the same liver were fixed in Regaud's fluid,

[1] Grateful acknowledgment is made to the Indiana Elks' Association for support of the electron microscope work of this study.

postchromated, dehydrated, embedded in paraffin, and stained for mitochondria with acid aniline fuchsin, with a counter-stain of methyl green. Still other pieces were fixed in 10 per cent formalin, prepared by the paraffin method and stained with hematoxylin and eosin.

For the electron microscope study several grids from each specimen were studied. The instruments used were of the RCA EMU-2 and RCA EMU-3E types.

With the light microscope only a rather extensive study indicates any change in the hepatic cells and this change either has to be worked out quantitatively or seen in individual aberrant cells. In other words, it is not a part of the readily observable total picture with the light microscope. A study of a number of fields of the liver reveals occasional large aberrant hepatic cells. Such cells also have tremendously large nuclei.

The mitochondria of the liver cells both in young and old animals generally are abundant. In the younger animals, however, the mitochon-

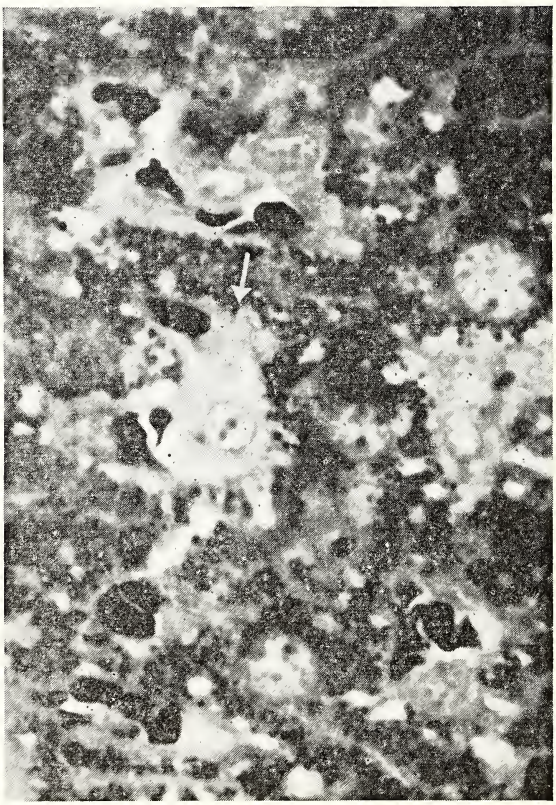

Figure 1: Liver of a senile male mouse as seen with high magnification of the light microscope. In some areas hepatic cells with very few or apparently no mitochondria are seen, such as the one indicated by the arrow. Regaud fixation, acid anilin fuchsin stain. X 1,900.

dria generally are more elongated. Study of the large aberrant cells in the liver of senile animals shows relatively little difference in the mitochondrial picture for such cells. There are, however, areas in the senile liver, particularly in regions where there is rather marked sclerosis of the blood vessels, where the mitochondrial picture is quite varied and where some cells are almost completely lacking in these cytoplasmic elements (fig. 1).

The details of structure of the hepatic cells and of other features of the liver as studied with the electron microscope have been presented in papers by Dalton et al. (8), Bernhard et al. (6, 7) and Fawcett (9).

Our initial studies with the electron microscope have included observations on hepatic cell nuclei and on mitochondria. In figure 2 we see the

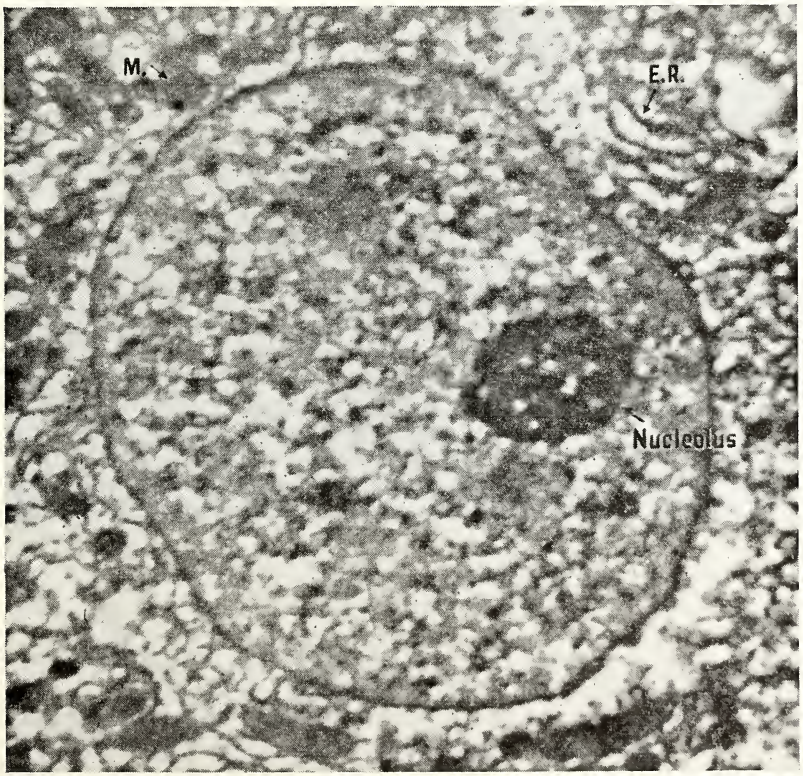

Figure 2: Electron micrograph of nucleus and part of the cytoplasm of an hepatic cell of a young adult male mouse. The nucleolus is large and conspicuous. E.R. = endoplasmic reticulum; M. = mitochondrion. X 26,000.

nucleus of an hepatic cell of a young mouse, 105 days old. The nuclear membrane is smooth. The interior of the nucleus shows a coarse network with some portions, denser than others, probably representing the desoxyribonucleoprotein. The nucleolus is conspicuous and shows a definite internal structure. In fig. 3, from a mouse of 664 days, we see the nucleus

Figure 3: Nucleus and part of the cytoplasm of an hepatic cell of an old female mouse. Nucleoli in older animals are less conspicuous than in younger. E.R. = endoplasmic reticulum; M. = mitochondrion. X 26,000.

of an hepatic cell in which the nucleoli, several of which are shown, are not as conspicuously marked off from the rest of the nucleus.

The hepatic cells show intranuclear inclusions in some pathological and experimental conditions. We have described such intranuclear inclusions as seen much more frequently in mouse and human liver in old age than in youth or "middle age" (4). An electron microscope study of such inclusions in the livers of six rats treated with thioacetamide and one human individual, a woman of 65 years suffering from cirrhosis of liver, has been made by Kleinfeld, Greider and Frajola (10). They have shown that these inclusions arise by an invagination of the nuclear membrane, a process which traps a portion of the cytoplasm. Thus the composition of the inclusion may be complex and include lipid, glycogen, and even cytoplasmic organelles.

In the present study we have noted that invagination of the nuclear membrane is of frequent occurrence in the liver of old mice (fig. 4), while

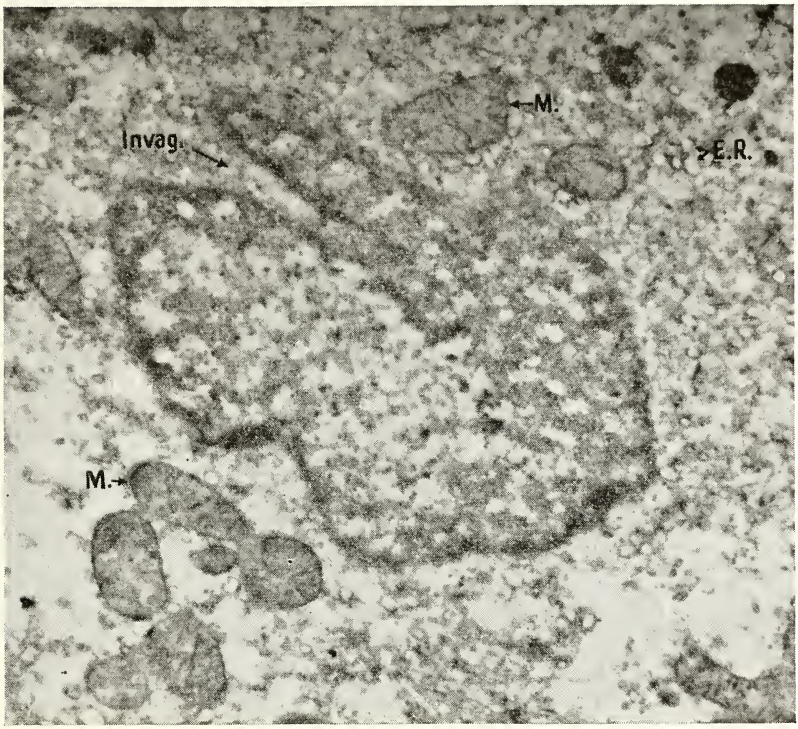

Figure 4 : Nucleus and cytoplasm of an old male mouse. Many nuclei in old mice show deep invaginations of the nuclear membrane. E.R. = endoplasmic reticulum ; invag. = invagination of nuclear membrane ; M. = mitochondrion. X 26,000.

we have not as yet seen it in our young animals. Such invagination would of course make the production of intranuclear inclusions more frequent.

Our study of the mitochondrial picture with the electron microscope has enabled us to make some correlation with light microscope findings and has revealed some additional facts. We have found the same kind of areas of "mitochondrial loss" in the sections studied by this method as we had seen in other senile animals with light microscopy (fig. 5). In the electron micrographs the cytoplasm usually shows a small number of rod-shaped or filamentous structures with the cristae or lamellar partitions which electron microscopists have come to consider as characteristic of mitochondria. Some of the ovoid or spheroid bodies also show such cristae, but many of them do not show them.

It has been pointed out by Fawcett (9) and by earlier authors that in fasting animals the liver mitochondria tend to pass from a rod-shaped or filamentous type to a granular or spheroidal form. It seems to us probable that such a change is occurring in the areas in which there is a tendency

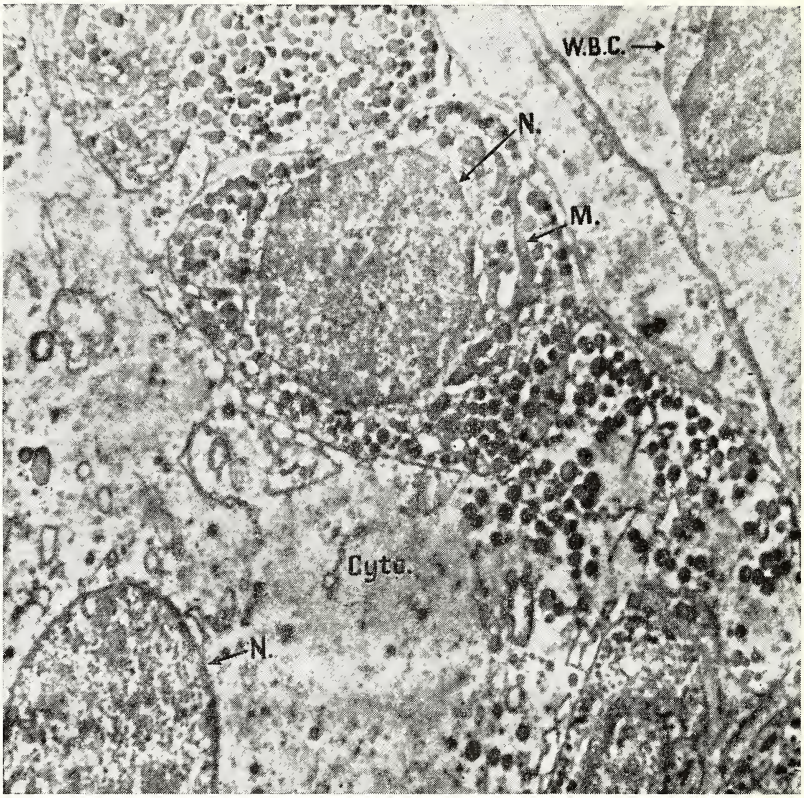

Figure 5: Low power electron micrograph of liver of an old female mouse. The unevenness of distribution of mitochondria in different liver cells is shown. Cyto. = cytoplasm; M. = a filamentous mitochondrion (most of the mitochondria shown are almost spheroidal); N. = nucleus; R.E. = reticulo-endothelial cell; W.B.C. = white blood corpuscle. X 12,600.

to actual disappearance of mitochondria, and that we are seeing here in addition some loss of internal structure in these organelles prior to their disappearance.

A contribution to the much discussed question as to how the mitochondria reproduce may well be expected from any study in which a careful and detailed observation of these organelles has to be made. We have seen a number of instances in the liver cells both of young and old animals in which mitochondria are constricted at or near the central portion and it has seemed probable to us that these do represent stages in division. We have not found any of the figures, so clearly shown by Fawcett (9) in which a partition extends across a mitochondrion to divide it into halves. It is known, however, that nuclei in amitotic division may divide either by constriction or by the formation of a partition, with later separation of the halves as daughter nuclei (1). It seems not unlikely to us that mitochondria also may have more than one method of division.

In conclusion, we may say that electron microscope study of age changes in one organ, the liver, seem to correlate well with light microscope study, to give added information, and to promise an opportunity for new and significant findings in the future.

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Origin and Release of Secretory Granules in the Anterior Pituitary of the Mouse—An Electron Microscopic Study[1]

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Only three decades have passed since progress in physics provided for the development of the first electron microscope. With its commercial availability and the application of new techniques, cytology is making a resurgence that has been unparalelled since the Cell Theory revolutionized the study of biology. We find ourselves speaking in angström (Å) units, a level of measurement which unifies biochemistry and physiology into the framework of morphology.

The mitochondrion is no longer studied by the beginning biologist as a simple tiny rod or filament, but as an important organelle with its own characteristic structure. The Golgi complex is no longer a possible artifact of fixation, but an organelle consisting of paired lamellar membranes, clusters of closely approximated vacuoles or cisterne, and small vesicles and granules. The ergastoplasm is no longer an amorphous basophilic component of the cytoplasm. Electron microscopy has shown it to be composed of a loose aggregate of double membranes often vesiculated and containing 100 Å particles. These are essentially the organelles with which our study has been concerned.

The early electron microscopic work of Farquhar and Rinehart on the anterior pituitary of the rat proposed distinct morphological cell types to be associated with the principal trophic hormones (3). These authors noted that true chromophobic cells classed as such with the light microscope are few, for when studied with the electron microscope they contain variable numbers of granules of characteristic size. In addition, these cells have a Golgi complex which is either close to one side of the nucleus or lying separated from the nucleus in the cytoplasm. This location of the Golgi complex has been used by many workers to distinguish acidophilic from basophilic cells. Farquhar and Rinehart, and Hedinger were the first to identify cell types by the difference in size of the secretory granules they contain (6). Through experimental physiological variation seven distinct types of cells have been characterized as to function; three basophils, two acidophils, one undifferentiated basophil-like cell and the true chromophobes. The basophils are thyrotrophs with 100 mμ granules, or gonadotrophs of the F.S.H. or I.C.S.H. type with 150-200 mμ granules. The acidophils are the S.T.H. cells with 350 mμ granules or the L.T.H. cells with 600 mμ granules. The undifferentiated basophil-like cells have been associated with A.C.T.H. Our observations using the pituitary of the

[1] This research was supported by the Indiana Elks' Cancer Fund number 40-821-39, and the U. S. Atomic Energy Commission.

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[3] Further acknowledgment is made to Bernetta Mason and Virginia Stott for their technical assistance.

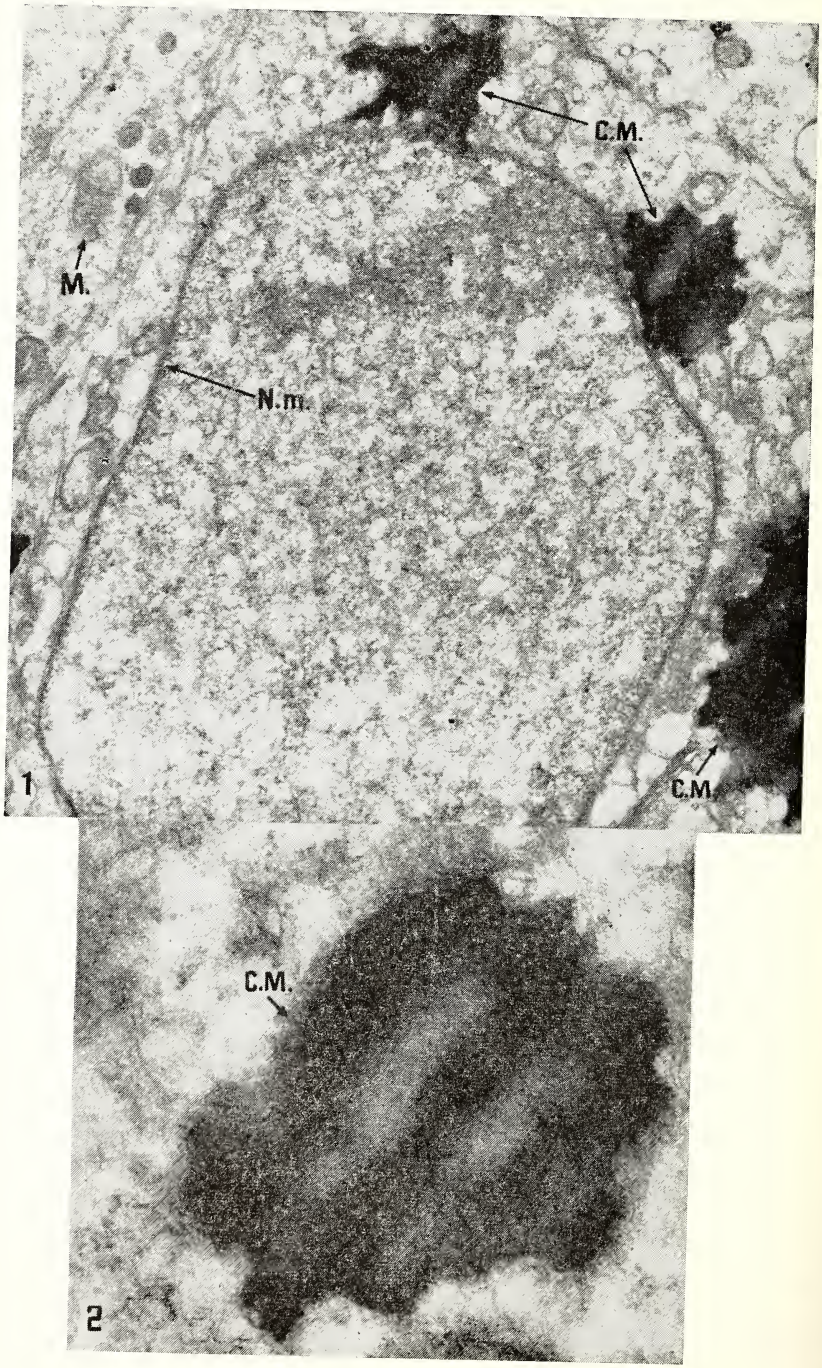
mouse and the recent study of others tend to support, at least in part, this morphological concept.

The site and mechanism by which a cell forms, segregates, concentrates, and extrudes its secretory product remains one of the basic unsolved problems of high resolution cytology (11). In an endeavor to gain insight into this secret of complex activity we have subjected the anterior pituitary of the mouse to various hormonal conditioned states. Alterations in the homeostasis of the animal by gonadectomy, thyroidectomy, inhibition of lactation and hormone administration have permitted observations on the characteristics of its cells not readily seen in an equipotential state. In mice studied at varying intervals of time after castration there is a progression of cytophysiological changes which are encountered in the anterior pituitaries (8). Until about 4-6 months there is an increased vesiculation of the endoplasmic reticulum of the gonadotrophic cells. The Golgi complex of these cells becomes more apparent than in the non-castrate control. The acidophils appear fewer, or at least less heavily granulated. With extended periods of castration numerous gonadotrophs contain a colloid of high electron density. The number of these colloidal masses increases steadily up to about 10 months castration. The size varies with the cell and often within one cell, especially in older castrates, more than one mass may be present. Since the appearance of castration basophils is obvious when these colloidal masses first appear it is easily established that the colloid is formed in gonadotrophic basophile (fig. 1).

High magnifications have suggested that these colloidal masses are formed by the coalescence of secretory granules. In the castrate mouse the lack of certain circulating steroidal hormones causes first an increased F.S.H. activity, evidenced by a high level in blood plasma. After about 4 months castration the gonadotrophs seem to be unable to release their secretory granules in a normal pattern causing what we refer to as "intracellular" secretion. In intracellular secretion the secretory granules coalesce, forming the colloid masses (8). In such an animal cycling of F.S.H.-I.C.S.H. levels ceases since the reciprocal gonadotropic-gonadal steroid relationship has been disrupted.

In the pregnant mouse there is a moderate increase in numbers of an acidophil cell type, which can be characterized by its content of very large secretory granules. At about the time of parturition, however, there is approximately a 100% increase in their proportion. In the 2-4 day lactating mouse the cell number has reached its zenith, nearly every field containing one or several of these acidophils. It has been repeatedly demonstrated that these acidophils, sometimes called pregnancy cells, are associated with the secretion of mammotrophic or lactogenic hormone. Experimentally, by preventing lactation, we have altered the degranulation of these cells (fig. 2). Our observations in these experiments have led to some interesting speculations, not only as to the release of secretory granules, but also to the formation of the secretory product of the cell. How might the ergastoplasm or endoplasmic reticulum, the mitochondria and the Golgi complex be vested in the phenomenon of cell secretion?

One of the most semantic controversies of cytophysiology is the involvement of the ergastoplasm in the biochemical processes of the cell. With the electron microscope the ergastoplasm has been described in

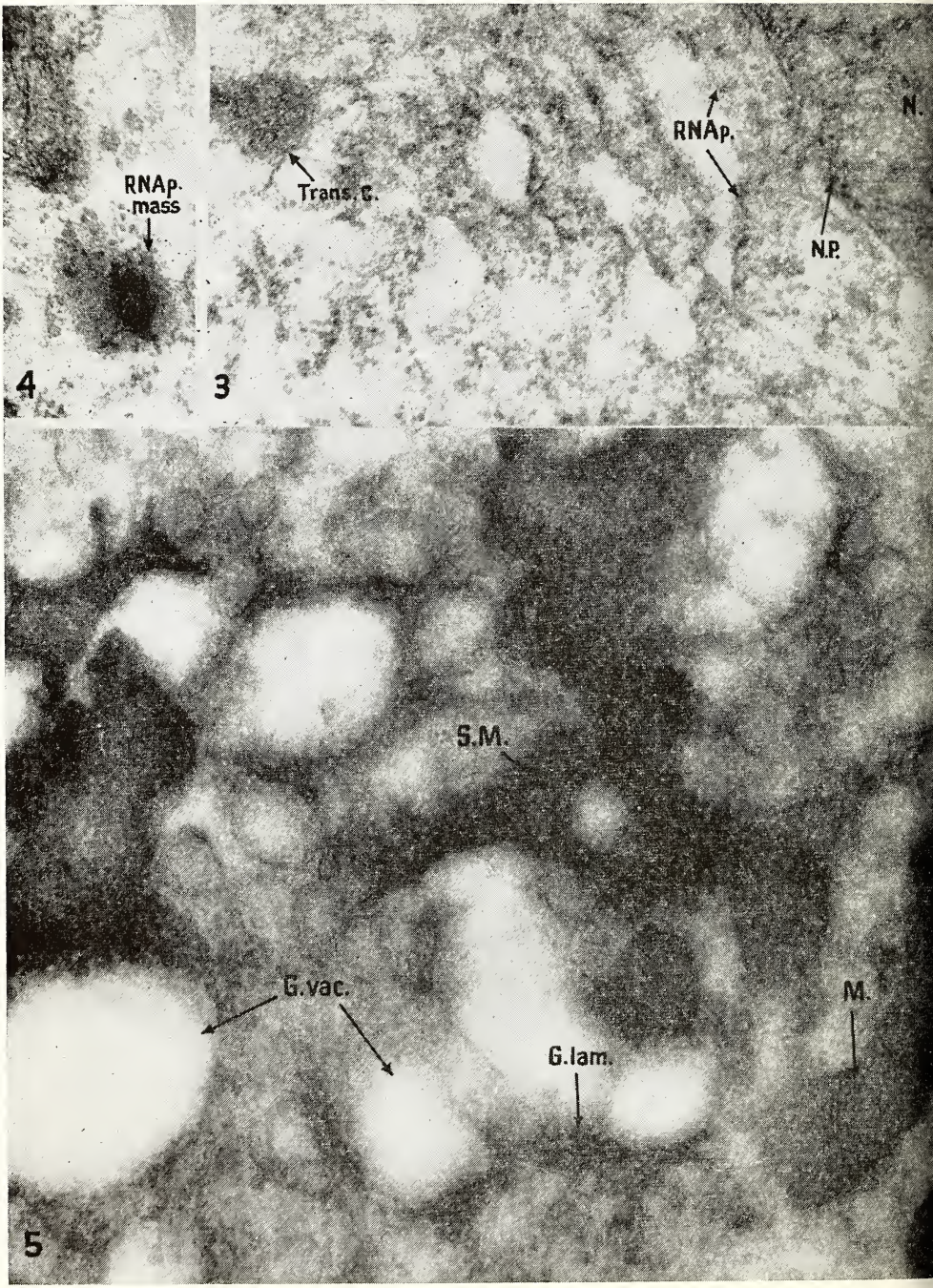

C.M.
M.
N.m.
C.M.
1
C.M.
2

numerous cells, appearing as a branching reticulum of the cell endoplasm. The term endoplasmic reticulum has been used by many investigators to denote such a system. In the cells of the anterior pituitary the endoplasmic reticulum may appear as a well formed organelle or it may show little organization into a reticular system. It would seem that the cells of the anterior pituitary are extremely sensitive to variations in tonicity. We have observed that chromophobic cells of basophilic or acidophilic classification have a relatively scanty reticulum which is smooth surfaced in profile. As the cell becomes larger and more differentiated the reticulum appears more organized and surface profiles are rough. Higher magnifications of the endoplasmic reticulum demonstrate that the roughness is due to the presence of small particles on the outer surface of the reticulum. As cell activities continue the endoplasmic reticulum becomes vesiculated with the particles somewhat larger and quite prominent. These particles are associated not only with the reticulum but with the nuclear membrane as well. A continuity of endoplasmic reticulum to nuclear membrane has been claimed by some authors, and our studies would lend support to this concept (7). In the cells of the anterior pituitary it would appear that these particles move along or with the reticulum to the nuclear membrane where they can be observed on both the cytoplasmic and nuclear sides. It would appear that these particles may diffuse through the nuclear membrane into the nucleus at any point in which they may come in contact.

Our attention to the changing physiologic states of the nucleoli in pregnancy cells would agree with the suggestion of Caspersson that the nucleolus is "a center" in protein synthesis. At the stage of particle diffusion the nucleoli of these cells are not markedly distinguishable. Shortly thereafter they become more electron dense, their striking change in density and their somewhat increase in size suggest a crux in the biochemical liability of the structure. Continued investigations into what we may consider the sequence of cell secretion suggest that the particles making up the nucleoli in some way, not yet morphologically understood, find their way to the pores of the nuclear membrane (9). These particles which on measurement seem to be somewhat larger than those particles which diffuse through the nuclear membrane pass through the pores into the ergastoplasm (fig. 3). In the ergastoplasm they may or may not show in profile a continuity with the reticulum. Numerous micrographs suggest that these particles coalesce in the ergastoplasm, forming homogeneous masses. Transverse cuts indicate that such masses can be directly associated with the reticulum or apparently free in the ergastoplasm. Preliminary histochemical observations on acidophils, cells which secrete a simple protein hormone, has suggested that here might be where ribosenucleoprotein becomes a templet in protein hormone synthesis (10), (fig. 4).

Fig. 1. Nucleus and surrounding cytoplasm of a gonadotrophic cell from a mouse castrated 4 months. Colloidal masses (CM) which are thought to be the coalescence of secretary granules. Mitochondria (M). Nuclear membrane (NM). X 36,000.

Fig. 2. Higher magnification of a colloidal mass. This mass was located in an acidophil from a mouse which was not permitted to lactate. Note the apparent similarity with those in fig. 1, though formed in different cell types under different physiological conditions. X 81,000.


RNAp. mass
4
Trans. C.
RNAp.
N.
N.P.
3
S.M.
G.vac.
G.lam.
M.
5

A more dense homogeneous material has been observed in the Golgi zone of anterior pituitary cells. At this point it becomes important to remember that protein synthesis, the actual production of secretory material, and secretory granule formation are far from one and the same. The author believes they are parts of a biochemical continuum, the morphological associations which we hope to elucidate further. The accumulation of the apparently unbound homogeneous electron dense material within the Golgi complex supports the concept that the area is directly involved in the secretory processes of the cell. It has been suggested by numerous investigators of various tissues, that the Golgi complex appears to be involved in secretory granule formation (4). The existence of secretory granules surrounded by Golgi membranes in the cells of the anterior pituitary has been viewed in our laboratory, and reported earlier by Farquhar. Our findings have suggested that a major step in protein synthesis takes place in the ergastoplasm, and that it is directly associated with the coalescence of "microsomal" particles. The presence of particles different in size and texture found only in the Golgi complex are believed to be involved with the actual production of secretory material (5). The vacuoles or cisterne, as suggested by Dalton (1), are probably involved in the condensation of the secretory material. The orientation of mitochondria with densely packed cristae toward the Golgi complex suggest that they are involved in the maturation of secretory material (2); a process that would undoubtedly require high energy bonds. The finding of homogeneous electron dense material within the Golgi complex suggests a material ready to be packaged and extruded from the cell (fig. 5). The observations of Golgi membranes virtually cutting into and surrounding portions of this material suggests the formation of secretory granules.

Another variant we have met, aside from the location of the Golgi complex, is that the form the complex assumes depends on the particular physiological state of the cell. We therefore believe that the Golgi complex is an important metabolic center in the secretory activity of anterior pituitary cells. Histochemical work has demonstrated that it is more than a packaging and wrapping station, but a center of vaguely understood complex activity. What determines secretory granule size may depend on the morphological location and structure of the Golgi complex. As a general rule the further away the complex from the nucleus the smaller are the secretory granules of the individual cell. It would seem that there is little association of secretory granule size to the molecular weight of anterior pituitary hormones. If an association does exist it is probably a biophysical one, in that those hormones essential to life (i.e. A.C.T.H. and T.S.H.) have smaller secretory granules permitting their

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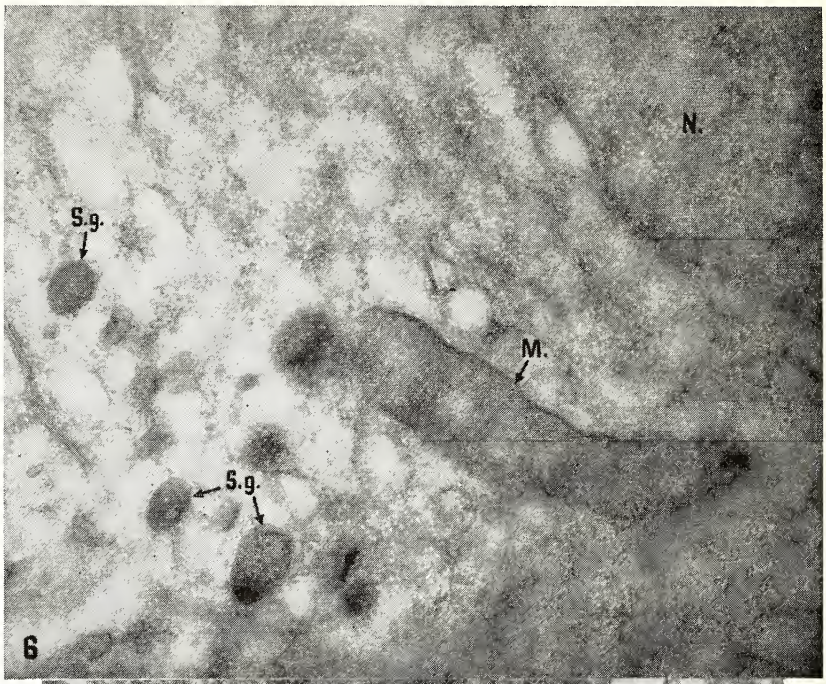
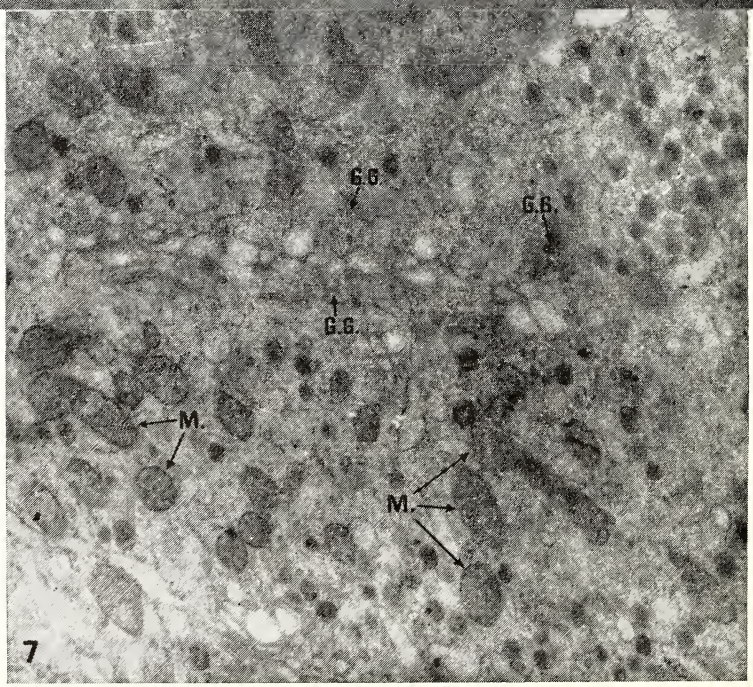
Fig. 3. Note the association of endoplasmic reticulum to nucleus by the nuclear pore (NP). RNA particles appear to be passing through the pore. Transverse cut of granules along the reticulum (Trans. C). X 144,000.

Fig. 4. A mass of RNA particles which appear to have coalesced in the ergastoplasm. X 144,000.

Fig. 5. Golgi complex of an anterior pituitary cell. The presence of homogeneous electron dense material within the Golgi complex suggests material ready to be packaged and extruded (SM). Golgi lamellae (G. Lam.). Golgi vacuoles (G. vac.). X 72,000.


N.
S.g.
M.
S.g.
6


G.G.
G.G.
G.G.
M.
M.
7

more rapid extrusion from the cell into the perisinusoidal spaces. It may be that individual secretory granule sizes are multiplies of hormone molecular weights (Fig. 6, Fig. 7).

It should be remembered that these declarations, regarding the formation and secretion within the gland, are hardly more than edified conjectures based on present experimental information. If these data prove our conjectures true, only much work and time will answer. As for conjecture, it is never worthless if it stimulates thinking. For as Dr. Jean Brachet, in his book Biochemical Cytology, states "Nowadays some scientists forget that thinking may sometimes be more useful than performing an experiment" (11).

Summary

The secretory processes of the anterior pituitary have been studied. Our observations have suggested that hormone production, as an example of the secretory process, involves the entire cell in a continuum of intergraded morphological and biochemical change.

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Fig. 6. Area of an acidophil showing mitochondria (M), secretory granules (Sg.), located in the cytoplasm close to the nucleus (N). X 72,000.

Fig. 7. The Golgi complex of pituitary acidophil at the stage when the nucleolus of the cell is quite dense. Note Golgi granules (GG), note also orientation of numerous mitochondria to the Golgi complex. X 38,000.

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